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INVESTIGATION OF THE EFFECTS OF CONSTRUCTION AND STAGE FILLING OF RESERVOIRS ON THE ENVIRONMENT AND ECOLOGY

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
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16. Abstract

Optical processing techniques are combined with manual photo-interpretation procedures to produce a system for analyzing space and high altitude photography. A simple system for copying, separating spectral bands, combining spectral bands, and contrast enhancement is explained. The photographic enhancement techniques and manual interpretation are compared to currently used digital processing techniques. The developed system proved to be a viable approach.

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PREFACE

This is the final report on the Investigation of the Effects of Construction and Stage Filling of Reservoirs on the Environment and Ecology. The overall objective of a series of investigations expected to be undertaken for this project is to test the hypothesis that changes in a river basin's ecology which take place during the construction and long-term operation of a flood control reservoir can be measured by high-level aerial and satellite photography and other data; in addition, the investigation attempts to ascertain whether post-project changes in areas having similar, preproject environments can be predicted with reasonable accuracy.

The purpose of this project was to develop optical processing techniques for use in a system to monitor the effects of major construction. A simple information extraction system, based on photographic enhancement techniques and manual interpretation, was developed and compared to currently used digital processing techniques. The developed manual interpretation system proved to be a viable approach.

The information extraction system described in this report was developed and tested by Dr. H. M. Karara and Dr. J. R. Eyton, Departments of Civil Engineering and of Geography, respectively, University of Illinois at Urbana-Champaign, Urbana, Illinois. Programming was done by Mr. Paul Lessar, a graduate student of the University of Illinois at Urbana-Champaign, Department of Urban Planning. Assistance provided by Mr. R. F. Gordon, technical monitor, is gratefully acknowledged.

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OVERALL OBJECTIVE

The overall objective of the anticipated series of investigations is to test two hypotheses: (1) that changes in the ecology of a river basin which take place during construction and long-term operation of a flood-control reservoir can be measured by high-level aerial and satellite photography and other data, and (2) that post-project changes in areas having similar, preproject environments can be predicted with reasonable accuracy.

The original area of interest was the Sangamon River Basin in Illinois. The phenomena that were originally to be observed included the effect of impoundment and operation of Oakley Reservoir upon such basic natural processes as erosion, sedimentation, primary production of organic materials, and changes in the composition and density of flora and fauna. These processes were to have been measured in the area immediately impacted by the reservoir itself, and would have included the zone in which changes in groundwater and soil moisture were expected to influence basin processes, as well as approximately 90 miles of land along the Sangamon River which were to be protected from flooding.

PROJECT OBJECTIVE

The purpose of this project was to develop a monitoring system with the objective of:

a. Developing a simple information extraction technique based on optical processing,

b. Developing an interpretation system compatible with the products of optical processing,

c. Testing these techniques against currently available digital processing techniques,

d. Evaluating the test results for use in the developed interpretation system for monitoring environmental changes caused by major construction.

The proposed dam site at Lake Decatur and a few scenes within the supplied imagery that could best illustrate the results are used as examples of the developed techniques.

2 SATELLITE-IMAGE OPTICAL PROCESSING TECHNIQUES

INTRODUCTION

This research investigates the utility and feasibility of optical processing techniques for the extraction of information from satellite images. The time expended on these information-extracting techniques is worthwhile for the following reasons:

a. Many people require techniques that will allow them to do "single shot" information extractions; therefore, the simplest and least expensive techniques that are effective were considered.

b. There are digital methods for these techniques; however, most current programs require considerable memory and are not adaptable to small computers. In addition, the expense of ERTS tapes or commercial digitizing of aerial photographs prevents their use by many investigators.

c. Most equipment described in this research can be built at a minimum cost and requires only minimal technical competence. This approach makes such optical investigations cost-effective and practical.

d. Remote sensors treat photographs as physical records of the radiation reflected from the ground. The optical processing can be carried out with the photographic image obtained from a point perspective sensing system (camera) or from a line scanning or videcon system. The important information (spectrally) is the indication of which band (wavelength) and how much of the radiation (intensity as indicated by grey level or density) is being reflected.

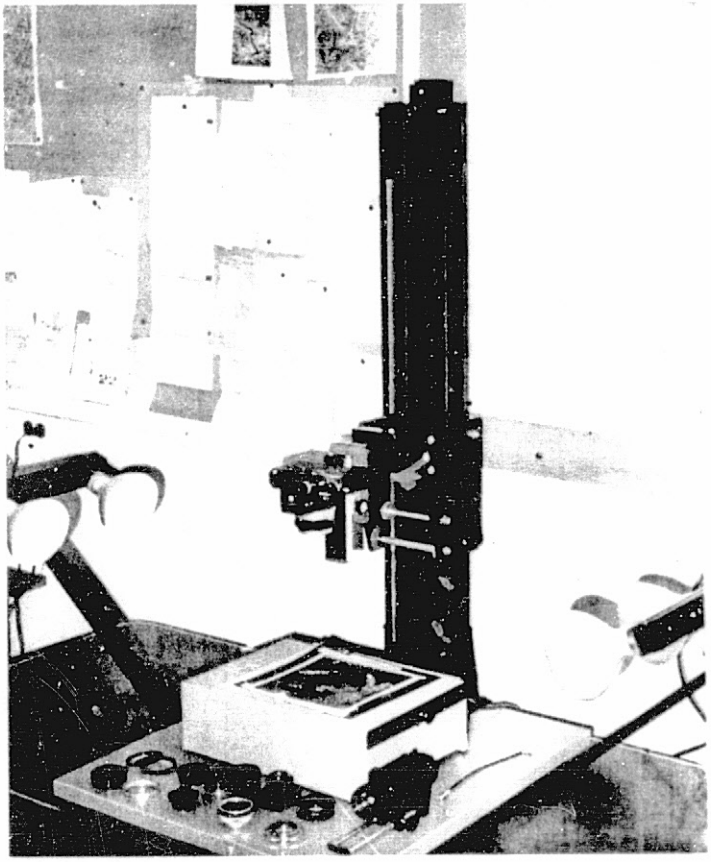
COPYING

Most information needed from an ERTS image is often contained in a small area of the image. Much of the initial research was an effort to obtain satisfactory enlargements of specific areas on the ERTS frame. Three methods were developed:

a. Use of standard copying equipment built around 35 mm and 2 1/4 x 2 3/4 in. single lens reflex cameras. Figure 1 illustrates the system and its components.

b. Fabrication of a simple camera (Figure 2) for obtaining a fixed 1:1 copy on 4 x 5 in. sheet film from a transparent or opaque copy.

c. Use of an enlarger to project portions of an ERTS color



1. Saturn Copy Stand
2. 3400 K Photo Floods
3. Aristo DA-10 Light Unit
4. Nikon F 35mm Camera
5. Micro-Mikkor-P.C. Auto 1:3.5 f55 mm lens
6. Bellows, Spiratone Macrotel 1:45, f 150 lens
7. Extension Tubes
8. +1, +2, +3, Close-Up Lenses
9. Spiratone Macrostigmat +20 Diopter Lens
10. Critical Focuser
11. Miranda FVT 35 mm Camera
12. Focusing Rail

Figure 1. Close-Up Photography System

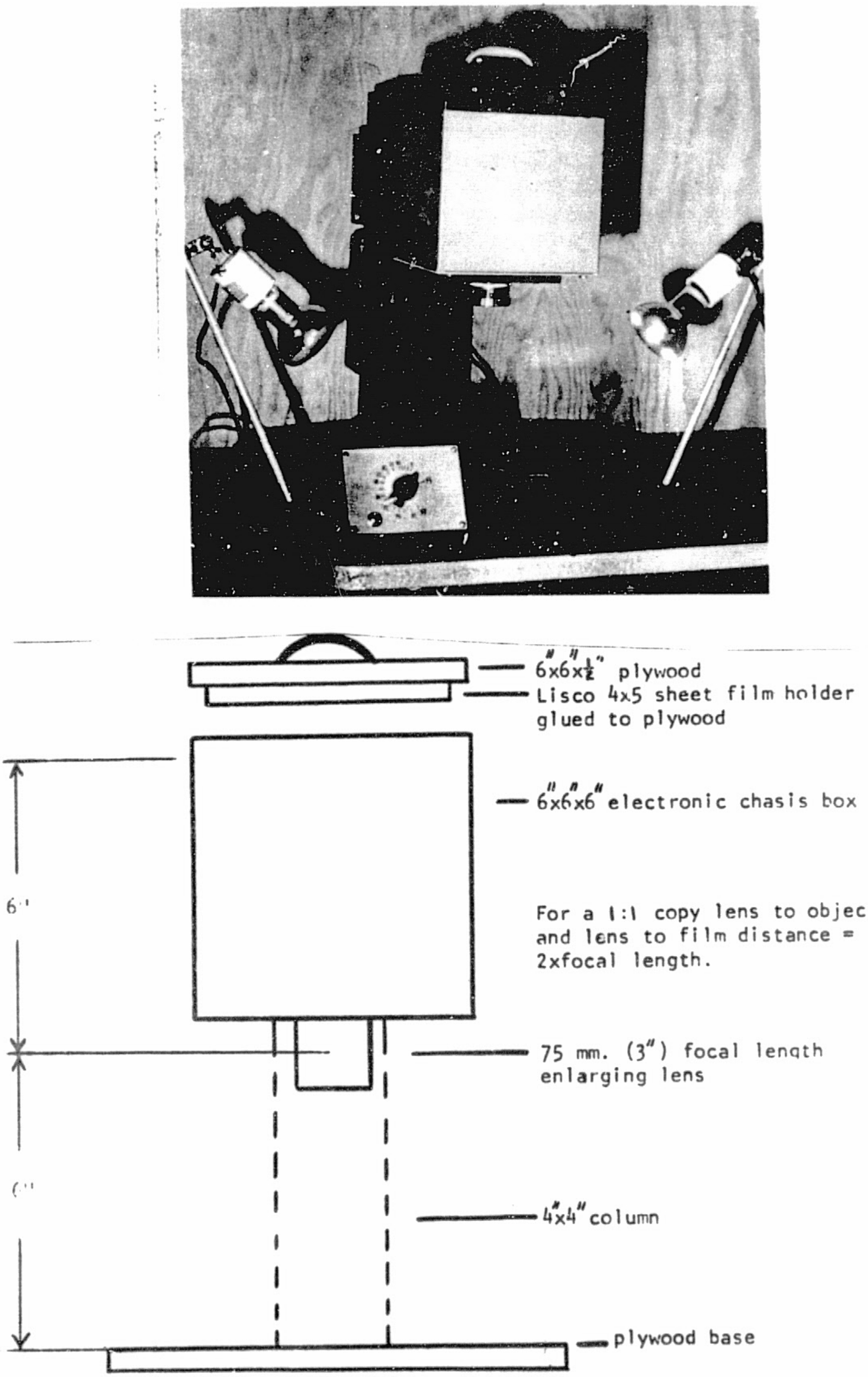


Figure 2. Simple 1:1 Copy Camera

transparency or enhanced Diazo transparency. This system produced the sharpest results at extreme magnification.

Table 1 outlines the steps for copying with the enlarger, and Table 2 outlines the necessary filtration for other enlarger bulbs and daylight-balanced films.

These three copying methods were quite successful. Contrast was increased by using standard film, such as Ektacolor or Ektachrome, rather than copying films which reduced contrast gain in the copying resean. Figures 3a and 3b illustrate the use of standard film. (All pictures contained in this report are referenced to an outline map shown in Appendix A.)

SEPARATING THE SPECTRAL BANDS

To obtain both a regular color image and an infrared color image, the spectral information of each band can be separated by photographing the image with black and white film using color separation filters. Two sets of separation filters can be used; an additive set (R, G, B) or a subtractive set (C, M, T). (Table 3 lists the Wratten number corresponding to each filter.)

The additive separation will be a black and white negative containing information from one band; the subtractive separation will be a black and white negative containing information from two bands.

Figure 4 schematically illustrates the process of separating the red band information from a color transparency.

The red radiation reflected from the target and recorded on the color transparency as Y and M dye is white in the final black and white print. This is the correct rendition for a positive black and white record of the reflected red radiation; white or light renditions indicate a high spectral return. Figure 5 shows separations from an IR Ektrachrome transparency using a simple target.

Table 4 shows the various combinations of separations from an Ektachrome transparency. The right column indicates the rendition of the black and white prints obtained by conventional black and white films and filters.

COMBINED SPECTRAL INFORMATION

Techniques used for combining black and white photographic records are additive viewing, additive printing, and additive copying. These methods are most commonly employed with multiband aerial photographic imagery and with the black and white photographic positives obtained from the ERTS multispectral scanner.

Table 1. Enlarger Copying of ERTS and SKYLAB Imagery

FILM: EKTACOLOR-L, 4 x 5 sheet for exposure of 1-10 sec, balanced for 3200°K lighting or daylight balanced films such as Kodacolor or Ektachrome

ENLARGER BULB: See Table 2

CORRECTION FILTER: (2950°K ⟶ 3200°K): 82B

FILM HOLDER: 4 x 5 Lisco sheet film holder. A white piece of paper is inserted on one side of the film holder to act as a focusing panel. The dark slide for this side is permanently removed.

STEPS:
(1) Put transparency in enlarger, <u>flipped over once from correct viewing</u>.

(2) Focus image at desired enlargement on white focusing panel.

(3) Turn film holder over; position holder with image on dark slide (DO NOT REFOCUS!)

(4) Turn off enlarger; remove dark slide and expose (nominal exposure 1 sec at f32 with 150 mm lens)

(5) Replace dark slide.

Table 2. Enlarger Bulbs and Color-correcting Filters for Balancing Tungsten and Daylight Films

Enlarger Bulb	Color Temperature °K	Color Correction Filters	
		Daylight Films	Tungsten Films (3200°K)
211 (75 Watts)	2950	80B & 82C	82B
212 (150 Watts)	2950		
300 (150 Watts)	3100	80B & 82B	82

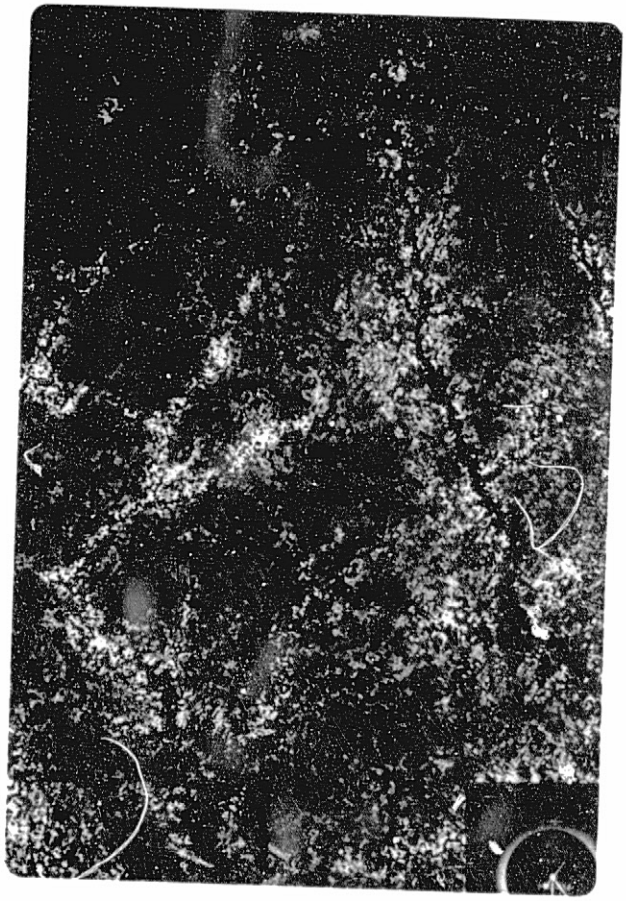


Figure 3a. Part of the Sangamon Basin (Map 1) from Skylab ETC Frame Copied Using Ektacolor-S

Figure 3b. Close-up of the City of Decatur, Illinois, and Lake Decatur (Map 2) from Skylab ETC Frame Copied Using Ektacolor-S

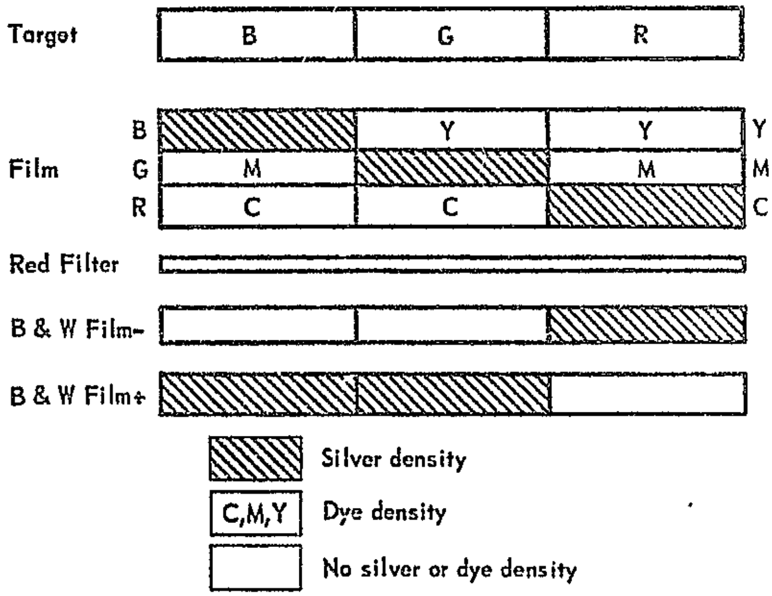


Figure 4. Separating Red Band from Ektachrome Film

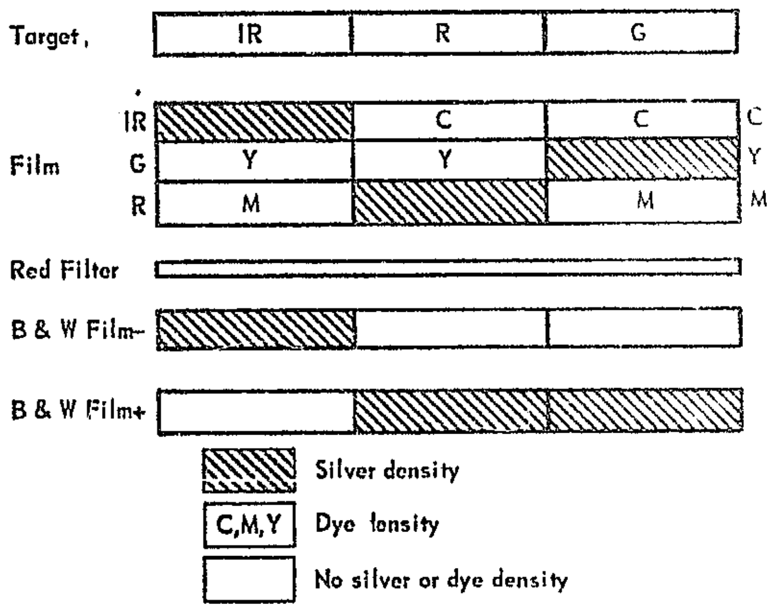


Figure 5. Separating the IR Band from IR Ektachrome (for the IR Ektachrome film a red filter separates out the IR information from the transparency because the IR response was represented by Y+M = R dye.)

Table 3. Separation Filters

Additive Filter	Wratten #	Subtractive Filter	Wratten #
R	25A	C	44A
G	58	M	32
B	47B	Y	12

The principal advantages of combining these records into a color composite are the operator's control over assigning a color hue to each band and the saturation of the color in sophisticated systems. Applications include false coloring (other than an IR Ektachrome rendition) to separate objects with nearly similar spectral reflectance or simply to combine images into a color composite if a color rendition is unavailable. The latter is particularly true of ERTS color imagery, since only certain color composites are readily available. The methods listed here will produce color imagery of extremely high quality, which in most instances will equal that of machine-processed imagery available from agencies.

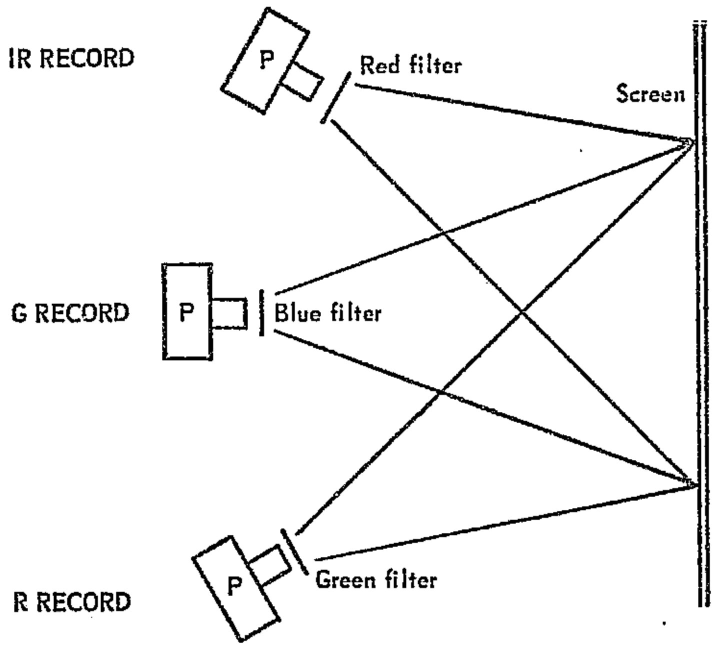
Additive Viewing

A simple additive viewing system can be made by using three projectors to project the black and white positive records in registration (aligned) on a screen. Filters placed in front of the projector lenses control the hue, and a rheostat connected to the projector bulbs controls, to a degree, the saturation. Figure 6 is an example of a simple system for reconstructing an IR Ektachrome rendition from black and white records. Since each record is a positive black and white photo, high radiation return is recorded as white (or transparent) on the film. If a red filter is placed in front of the projector containing the IR record, areas of high IR reflectance will be red on the screen. Adding a green filter in front of the projector containing the red record and adding a blue filter in front of the projector containing the green record will create an IR Ektachrome rendition. Other false color renditions can be obtained by interchanging the filters.

It is possible to construct a simple system such as that shown in Figure 6, but there will be registration problems unless long focal length (long throw to screen) lenses are used. Even when these lenses are used, however, perfect registration is still impossible. Perfect registration can be insured by using beam-splitting mirrors (Figure 7). Table 5 indicates some of the color combinations possible when a set

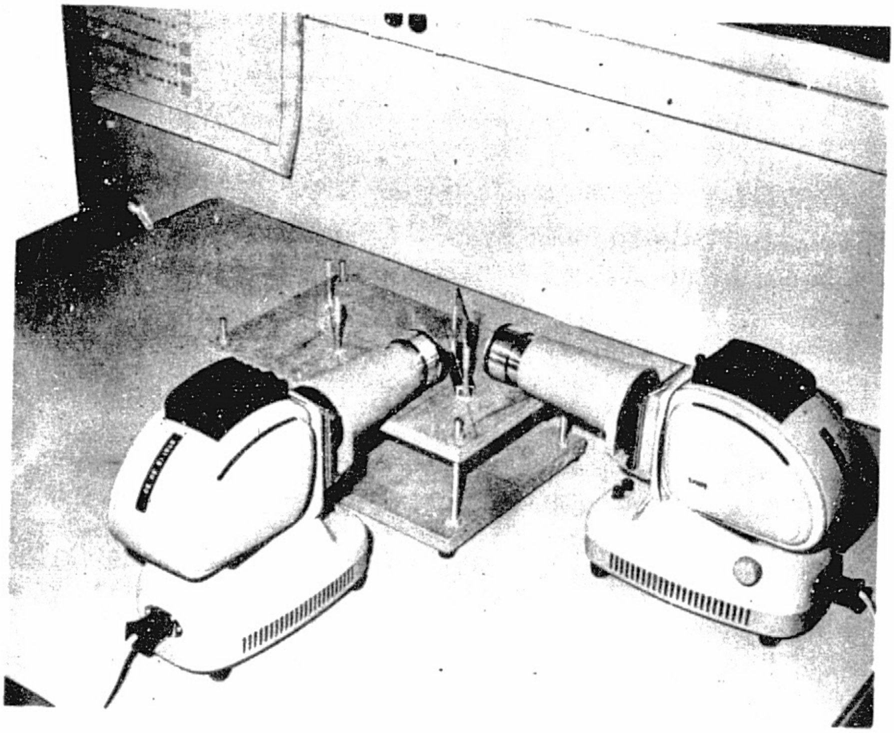
Table 4. Black and White Prints from Infrared Ektachrome Transparency

Record	Dye Layer	Separation Filter	Equivalent Black and White Film/Filter Combination
Infrared	Cyan	Red (25A)	IR + 89B
Red	Magenta	Green (58)	PAN + 25A
Green	Yellow	Blue (47B)	PAN + 58
Infrared and red	Cyan and Magenta	Yellow (12)	IR + 25A
Infrared and green	Cyan and Yellow	Magenta (32)	No equivalent combination
Infrared & red & green	Cyan, Magenta & Yellow	No filter	No equivalent combination
Red & green	Magenta & yellow	Cyan (44A)	PAN + 12



P Projector with positive B & W transparency of each record

Figure 6. Additive Viewing System



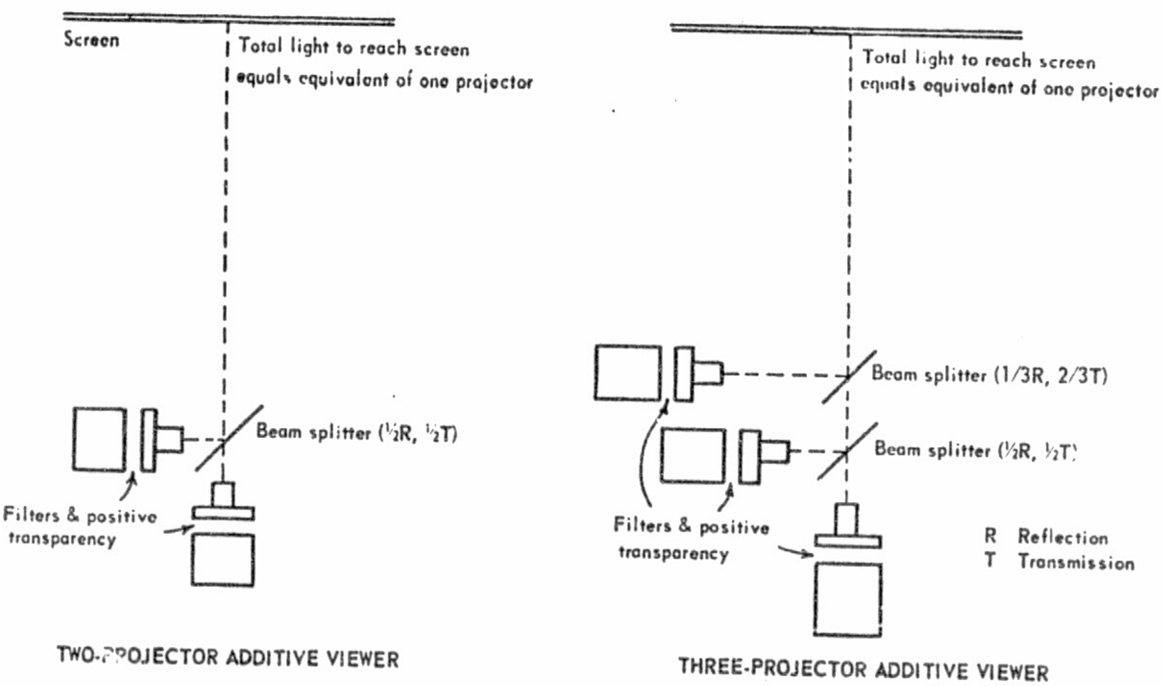


Figure 7. Beam Splitter Additive Viewing Systems

of primary additive and subtractive filters are used. With these filter combinations, the non-IR reflectance color is complementary to the IR reflectance color, providing maximal scene contrast.

Table 5. Filter Combinations for Additive Viewing

	Records			IR	Non-IR
	IR	R	G	Ref. Color	Ref. Color
PROJECTION FILTERS	R	G	B	R	C
	B	G	R	B	Y
	G	B	R	G	M
	C	M	Y	C	R
	M	C	Y	M	G
	Y	C	M	Y	B

For most small-scale imagery, little information is lost if the green record is not used in the additive viewer. In practice, this may result in an actual gain in information, since two images are much easier to register than three. The green record is also subject to greater radiation scattering and usually does not have the contrast of clarity of the red record. Complementary-colored filters always have a two-band representation. When a red filter is used with the IR record and a cyan filter is used with the R record, the rendition will be nearly identical to that of the IR Ektachrome rendition. Using one band in the near infrared and one band in the visible creates a much easier projection system; it is also a very useful concept for carrying out spectral enhancement techniques.

Additive Printing and Copying

The same procedures used for additive viewing may be used to make color prints or transparencies from individual black and white records. If black and white positive records are used, they must be copied onto color-positive material. If black and white negative records are available, they can be copied or printed onto color negative materials.

Additive printing is a method in which the black and white record is placed in contact with a piece of colored material and exposed to a light source filtered by a primary filter. The second and third records are then individually contacted to the same piece of paper and

exposed to the light source through a different primary filter. Each record is kept in registration by a pin registration system. Two approaches may be used: printing black and white negative records onto colored paper (such as Ektacolor RC) which yields a positive color print, or printing black and white positive records onto a color negative film and using it to make contact color prints. The latter approach is basically the one used by the EROS program to print color composites from ERTS data. Figures 8 and 9 show the reconstruction of an IR Ektachrome rendition color print from black and white positive and negative records. False coloring of any rendition other than the IR Ektachrome rendition can be accomplished by interchanging the printing filters.

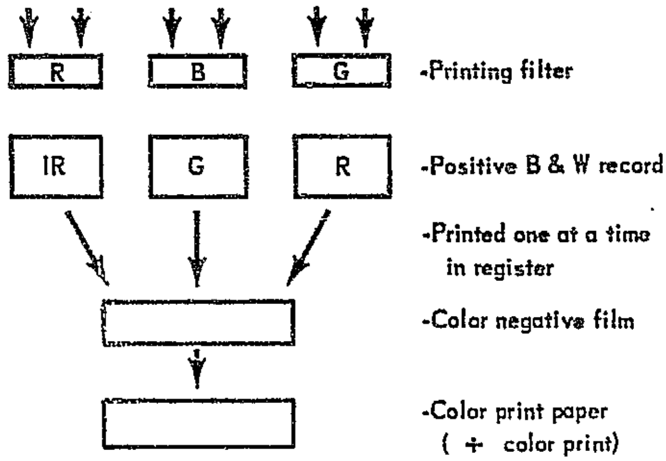


Figure 8. Infrared Ektachrome Rendition from Additive Printing of Positive Black and White Records onto Color Negative Material

Additive copying can be accomplished by backlighting the black and white records and photographing them with a camera containing either positive (Ektachrome-X) or negative (Kodacolor, Ektacolor-S) film. Filters are interchanged on the camera lens for each exposure of a black and white record. A camera, such as a Mamiya RB-67 2-1/4 x 2-3/4 in. SLR that is capable of triple exposure is ideal for this work.

CONTRAST ENHANCEMENT

Increasing the contrast of a color composite may increase the viewer's ability to distinguish detail more readily and note color

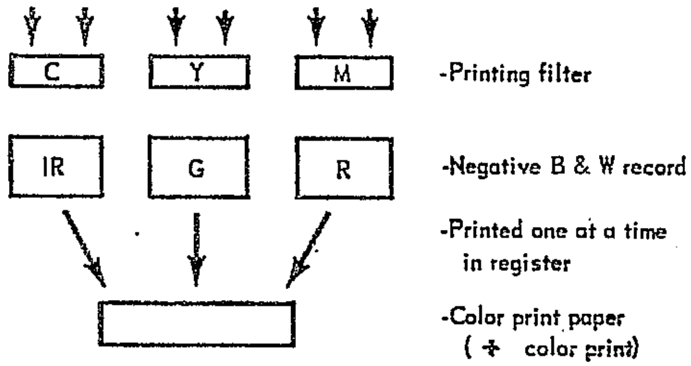


Figure 9. Infrared Ektachrome Rendition from Additive Printing of Negative Black and White Records onto Color Paper

differences between objects which reflect nearly similar amounts of radiation bands. This can be accomplished in several ways:

a. By photographing a color image (e.g., an IR Ektachrome air photo or an ERTS color composite) with a high-contrast color film such as Ekco photomicrography color film 2483.

b. By taking separations from an IR Ektachrome file and developing them to a high contrast. The high-contrast separations are then combined by additive viewing or printing.

c. By contact printing black and white positive records onto a high-contrast color material such as Diazo and registering the Diazo images to make a high-contrast color transparency.

Contrast Enhancement Using Photomicrography 2483 Film

Photomicrography is the use of a high-contrast Ektachrome film that is balanced for daylight and capable of very high resolution. Used in conjunction with a macro lens for closeup photography, it is extremely useful to the remote sensor for producing highly detailed images of a small portion of an air photo or ERTS image. In addition, the high-contrast color rendition often enhances small color differences. The film is available in 135 magazines of 36 exposures and 4 x 5 in. sheets. The film's principal disadvantage is its slow speed--ASA 16; however, this is usually not a problem if closeup photos are being taken and the camera is mounted on a rigid copy stand. Used in

conjunction with an Aristo daylight source and copying at 1:1, nominal exposure for copying portions of ERTS color transparencies is 1/2 sec at F/5.6. Figure 10 is a photomicrography enlargement of an ERTS frame (1:1 on the original 35 mm frame).

Contrast Enhancement from High-Contrast Separation Records

Black and white high-contrast negative separation records may be obtained from an IR Ektachrome air photo or from an ERTS color composite, using EKCO high-contrast copy film 5069. This film is a high-contrast panchromatic black and white film of high definition and is available in 135 magazines. When obtained, the separation negatives can be contacted onto a continuous tone sheet film, such as Plus-X, to obtain positives. These can be used in the additive viewing or printing techniques. The process of obtaining high-contrast positives can be carried further by contact printing the negatives onto a line film, such as EKCO Ortho Type 3 or Professional Line Copy. This results in a positive black and white record which contains either a dense black image (no radiation return) or a completely clear image (high radiation return). This "yes-no" quality of the record is called (by the authors) a binary slice. If each binary-sliced record (IR, G, R) is colored by additive printing or viewing, there will be a maximum fixed number of tonal classes in the scene. Table 6 outlines the possible combinations for binary-sliced IR, G, R records. Figure 11a is an enlargement from an ERTS color composite with no enhancement; Figure 11b is a binary of the same image.

Contrast Enhancement Using Diazo

This process is perhaps the simplest and most effective enhancement process. Diazo is a nonsilver ultraviolet light-sensitive positive material available in many colors, including red, green, blue, cyan, magenta and yellow. It is a high-contrast material that is easily developed in an enclosure containing ammonia vapors. If a positive black and white record is contacted or printed with this film, it will yield a positive color rendition. This makes it particularly useful for the construction of color composites from black and white positive, bulk-processed ERTS transparencies. If only the IR ERTS and the R ERTS records are used, the final transparency will be approximately equal to the color composite produced by three records (IR, R, G)

The detail retained by this process is easily equal (in the authors' opinions) to that of the EROS paper color composite, and in some cases, detail is added. To produce the IR Ektachrome rendition of an ERTS image, the following steps are necessary:

a. The IR record is contact-printed with a piece of cyan Diazo and developed.

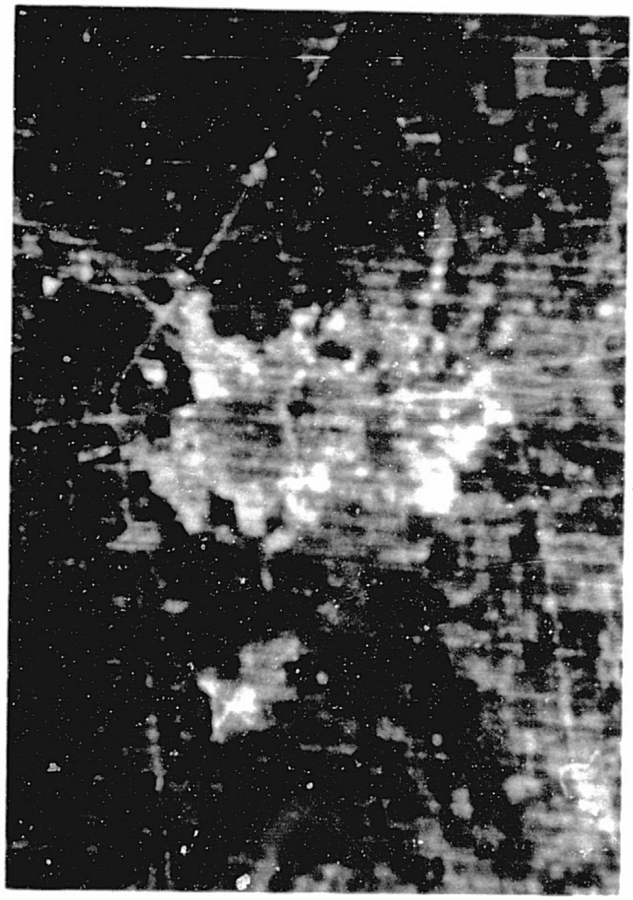


Figure 10a. Copy of Champaign-Urbana Area from ERTS Color Composite Unenhanced (Map 3)

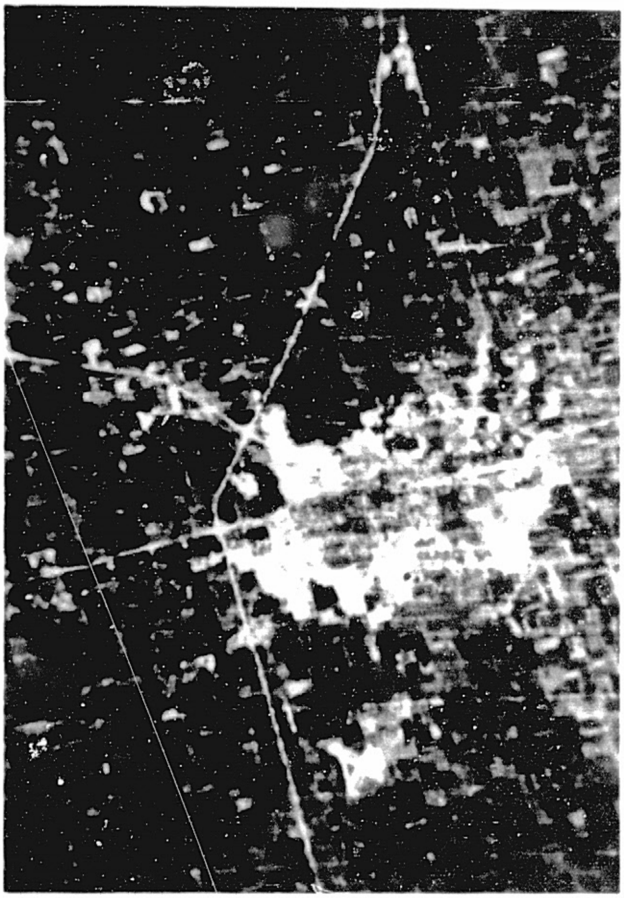


Figure 10b. Copy of Champaign-Urbana Area from ERTS Color Composite, Using Photomicrography (Map 3)

Table 6. Binary Slicing Combinations for IR, G, R, Records

Record ↑ IR/R → Color of Final Additive View or Print	IR/R	G/B	R/G	Resulting Color of Additive View or Print
	H	H	H	White
	H	H	L	Magenta
	H	L	L	Red
	H	L	H	Yellow
	L	L	H	Green
	L	H	H	Cyan
	L	H	L	Blue
	L	L	L	Black

H = High return of radiation; L = Low or "no" return of radiation

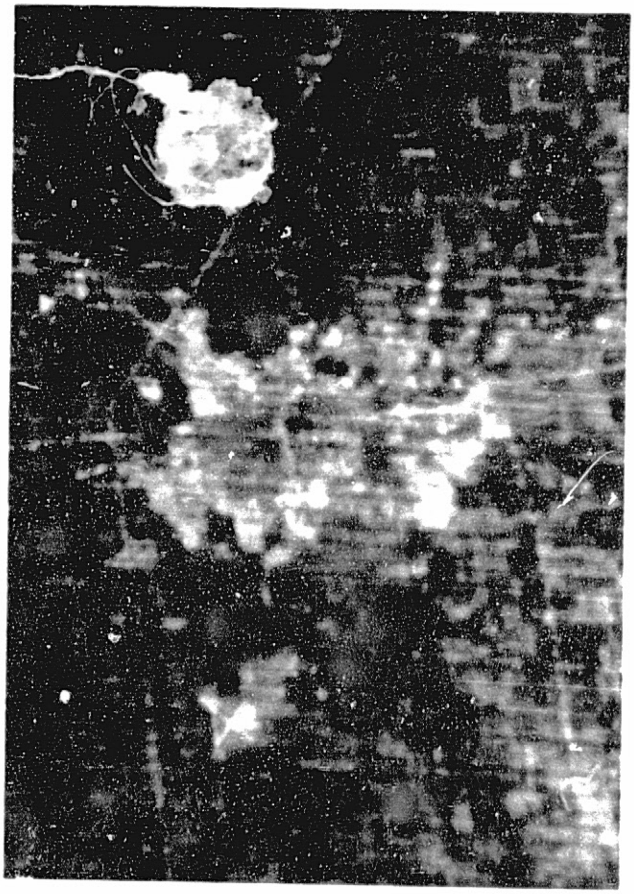


Figure 11a. 1:1 Copy of Champaign-Urbana Area from ERTS Color Composite, Unenhanced (Map 3)

Figure 11b. Binary Sliced Composite of the Same Image as in Figure 11a (Map 3)

b. The R record is contact-printed with a piece of red diazo and developed.

c. The two images are registered and taped. This step is relatively easy, since registration marks are part of the ERTS images. To insure proper exposure of the fine registration crosses, it is sometimes helpful to tape a small piece of paper over the registration mark on the back side (toward the light source) of the black and white records.

Very little experimentation is necessary to obtain proper exposure of each image, and the process is inexpensive (20¢ per Diazo sheet). Figures 12a and 12b are enlargements of a two-color Diazo composite.

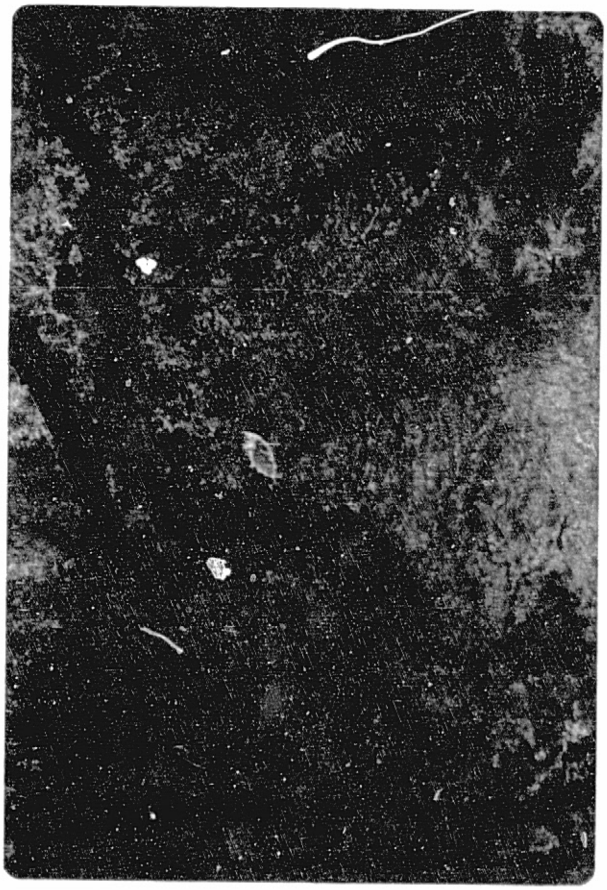


Figure 12a. Approximately One-Third of an ERTS Frame of St. Louis, Missouri, Area, Copied from EROS Color Composite (Map 5)

Figure 12b. Close-Up of the St. Louis, Missouri, Area from a Diazo Color Composite (Map 5)

3 INTERPRETATION TECHNIQUES

INTRODUCTION

There are two approaches for interpreting the ERTS images: a manual-photographic system, which could be used to record data in a format convenient for computer mapping, and a digital interpretation derived from statistical analysis of an ERTS tape.

MANUAL INTERPRETATION

A fairly simple interpretation system was devised that was capable of using 35-mm copies of ERTS imagery or 35-mm copies of enhanced ERTS imagery. The system was built around an easily built projection unit (Figure 13). Within this system, raw maps can be constructed or current maps can be updated. The projector is free to slide within the projection unit, thus allowing a wide range of enlargements. For example, if an urban area appearing on an ERTS image (1:1,000,000) is approximately 1/2-in. square in area, is copied at 5X magnification, and is projected to a 10x enlargement, it will be more than 20 in. square. By using this projection unit, imagery of different dates, scales, and formats can be compared, overlain, or projected.

The approach to this interpretation was based on the concept of separating the image into regions of homogenous tones. The operator first viewed the projected image on the drafting paper and tried to separate a standard set of tones within the image. Use of 8 x 10 in. filters* on top of the projection paper aided in distinguishing a set of tones and later in discriminating between similar tonal areas.

Two recording mechanisms were chosen: one to pencil out and code areas on the drawing paper from which a simple outline map could be made; and one to record the tones on a gridded sheet either by striking out and labeling cells containing similar tones or by color coding them. The first format may be accomplished rapidly but presents problems in determining boundaries between two different tonal areas. The second format uses a cell sampling scheme and reduced the problem to one of border discrimination. The interpreter determines the dominant tone of every cell and assigns the code to each.

An important advantage of the cell or grid sampling interpretation method is that the resulting coded interpretation can be keypunched and processed further by computer. Although card coding and punching is a tedious operation for large maps, the effort is justified. Many sets of computer maps can be easily printed by the machine, and several

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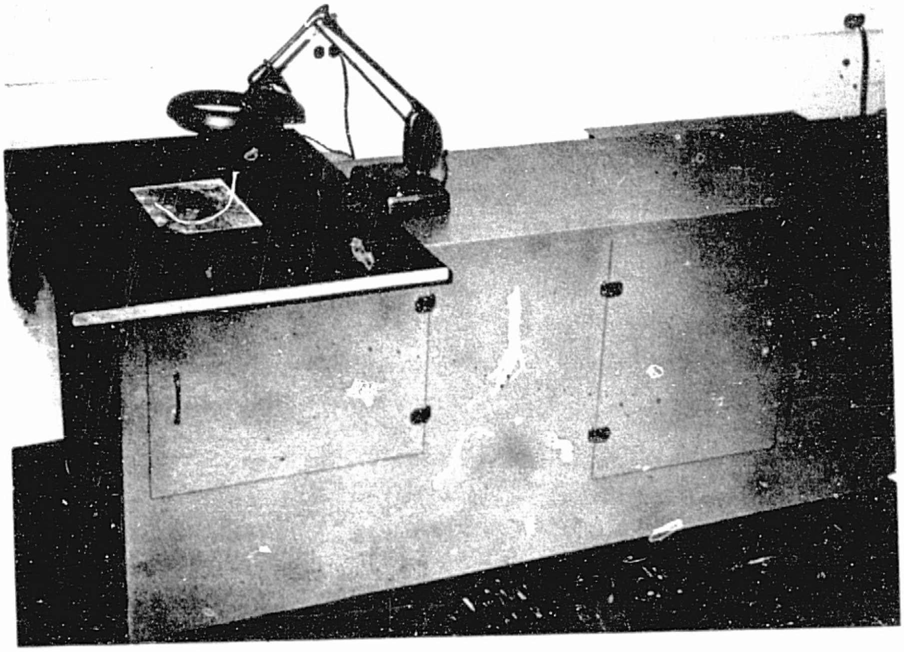
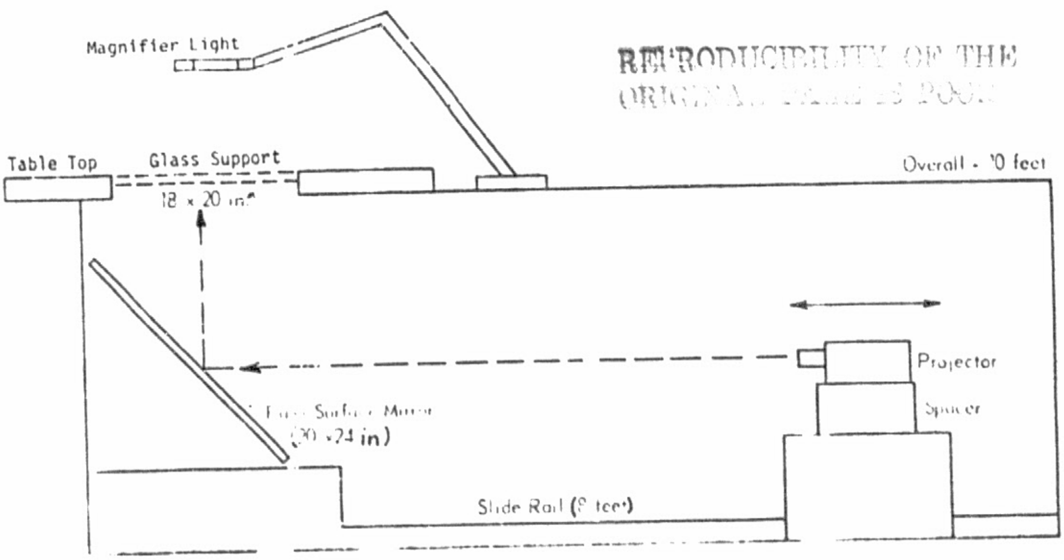
* Edmund Scientific Corp., Catalog #70638.





Throwback Projector

Figure 13. Throwback Projector Interpretation System

manipulations of the data matrix are possible. (These are discussed in greater detail in the interpretation results section.)

Since line-printed maps were the end product, the gridded sheets used to sample the image were designed so that the cell sizes were compatible to the computer line-printed output. Appendix B contains the program for producing these grid sheets and instructions for using it.

This system may be used in either mapping mode, is easily operated, and has considerable flexibility. It is both inexpensive to set up and economical to use.

MACHINE-PROCESSED STATISTICAL INTERPRETATION

Classification of ERTS digital tapes was carried out as an alternative to the manual methods of interpretation. Training fields were selected and a statistical cluster analysis was performed on training field data. A discrimination function arranged the data of the entire image into the number of classes determined by the cluster analysis. This was completed for the digital data of the scene used in the manual interpretation method.

INTERPRETATION RESULTS

A portion of an ERTS image was tonally analyzed with the manual method by using a high-contrast color photomicrography, 35-mm copy of the Lake Decatur area (Figure 14). Since tonal boundaries were more readily apparent and easier to determine, the color photomicrography was used with the gridded sampling scheme. Figure 15 is a color-coded photographic reproduction of the grid sheet. Several attempts at determining distinguishably separate tones resulted in nine tonal classes being used to map the image. The color-coded grid sheet was converted to digital data and processed by a computer mapping program (Appendix C contains the program's instructions and listing). Another option of the program is to print a map showing each class individually. This is invaluable for correlating the tonal regions to collected ground truth or for comparison with underflight imagery.

Appendix C illustrates the class at a time tonal classification and shows the line-printed classified map and the frequency (area) statistics associated with each class. Figure 16 is a tentative "truth table" for each tonal region. Since no ground truth evaluation applied to the project, comparisons of the tonal regions were made using underflight imagery (Figure 17). Since the area of the test encompasses about 1/200 of the area of an ERTS frame, the details recorded by this method are impressive.

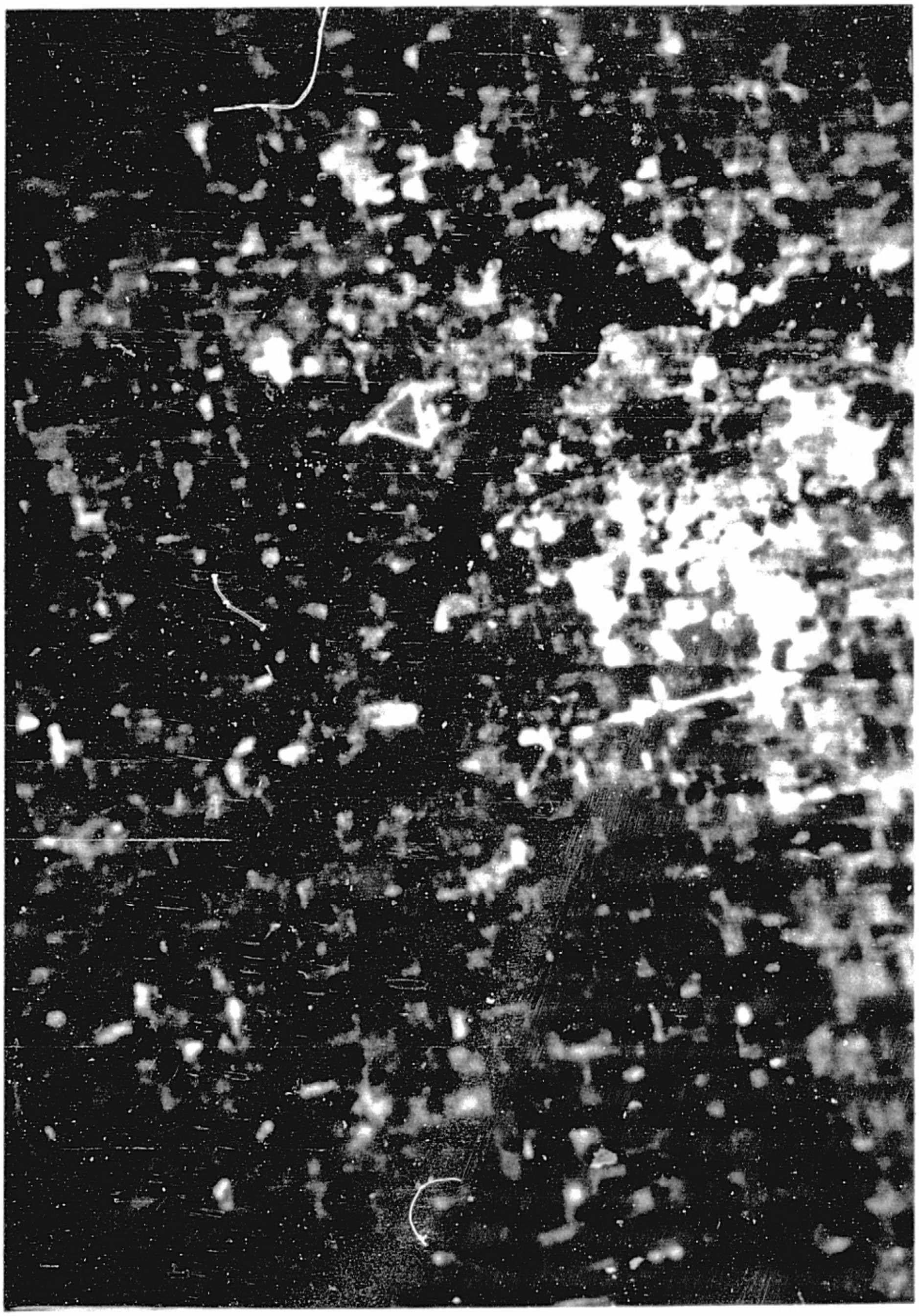


Figure 14. Color Photomicrography 35-mm Copy of ERTS Imagery

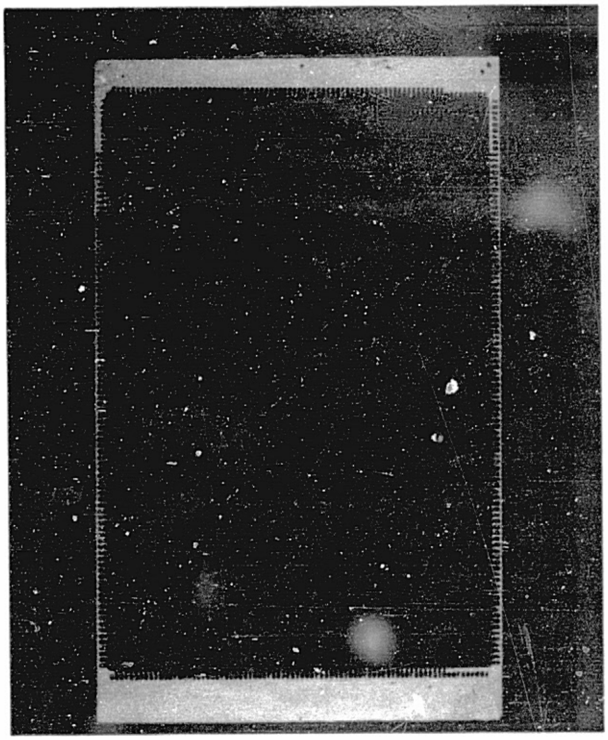


Figure 15. Color-Coded Grid Interpretation

CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)	CLASSIFICATION
1	⋮⋮⋮	579	0.09	7.5	Water
2	=== === ===	412	0.06	5.4	Concrete (Runways, Parking Lots, Interchanges)
3	+++ +++	48	0.01	0.6	Vegetation (Swampy Areas, Vegetation mixed with Water)
4	000 000 000	2023	0.32	26.3	Vegetation (Grasses associated with Parks, Golf Courses, Residents)
5	||| ||| |||	1989	0.31	25.9	Open Space (Bare Soil or Cindered Lots)
6	θθθ θθθ θθθ	125	0.02	1.6	Old Residential (Mixture of Vegetation, Roof Tops and Streets)
7	ØØØ ØØØ ØØØ	99	0.02	1.3	Industrial (Large roofed-over areas, gravelled lots)
8	ØØØ ØØØ ØØØ	170	0.03	2.2	Vegetation (Dormant Grasses and Stubble Fields)
9	ØØØ ØØØ ØØØ	2235	0.35	29.1	Vegetation (River Bottom Vegetation and some Crop in Rural Areas
		7680	1.20		

Figure 16. "Truth Table" for the Tonal Regions Used in Appendix C

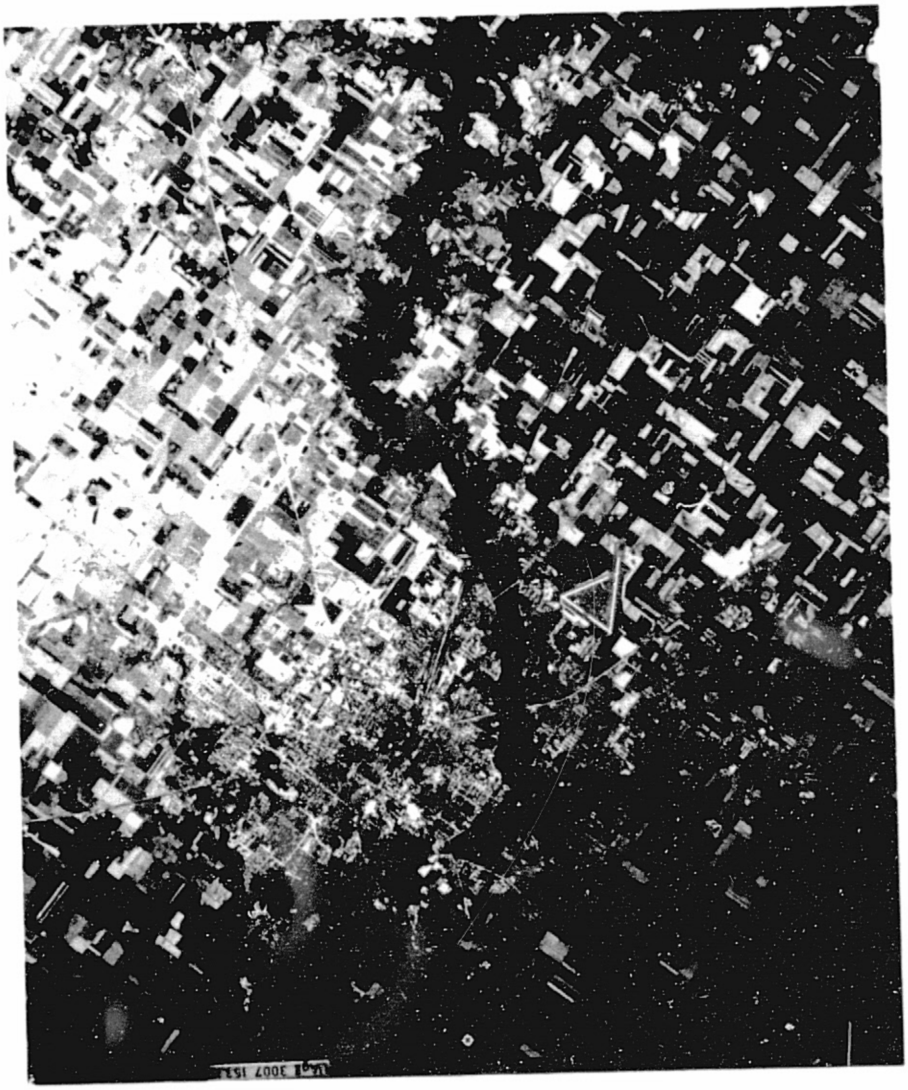


Figure 17. Underflight Image of the Decatur, Illinois, Area

Figure 18a. Color-coded Composite of the Classification Indicated in Figure 16 (Classes are indicated on the following one-class-at-a-time displays--Figures 19b through 19g.)

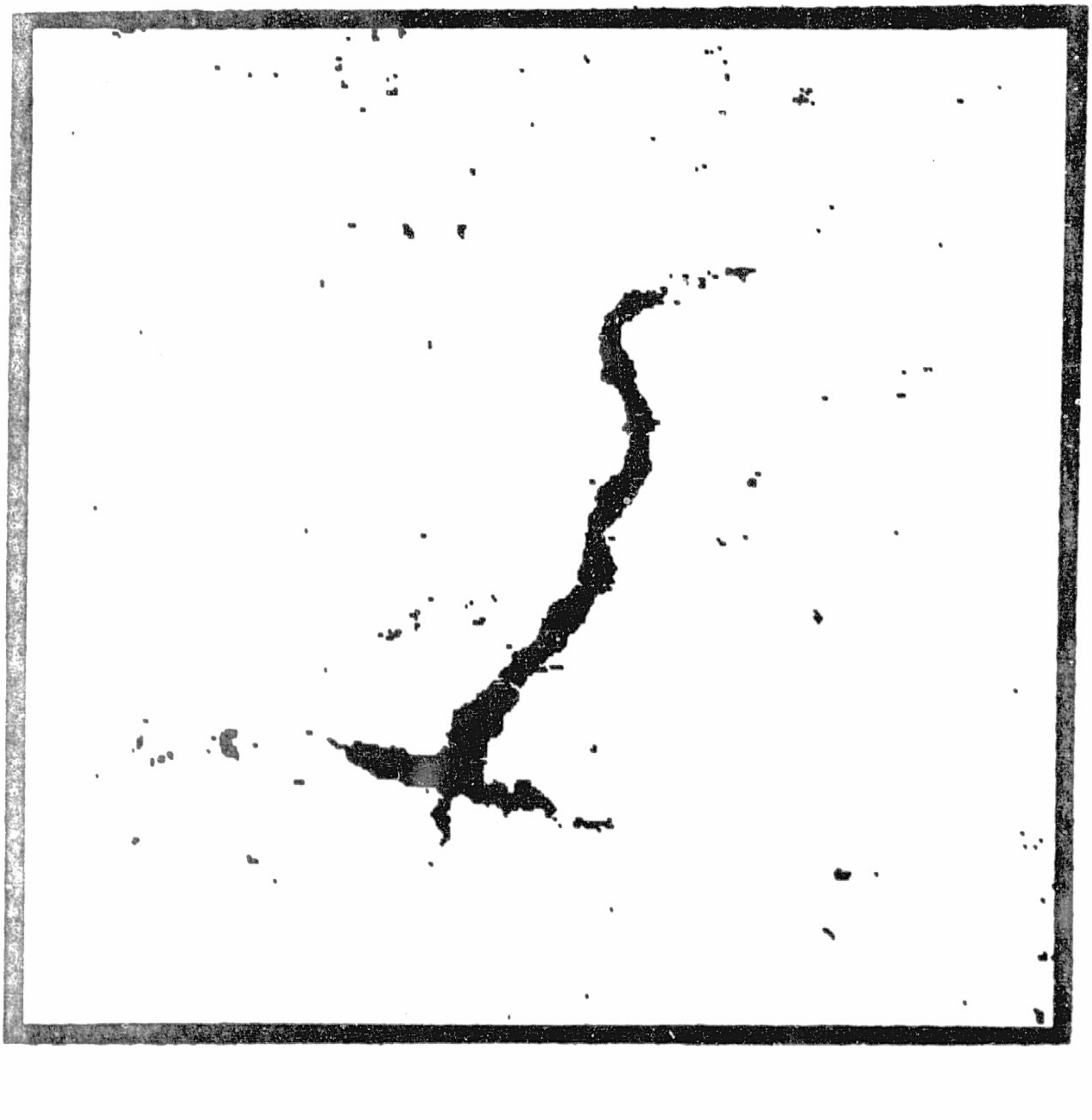


Figure 18b. Display of the Blue Classification (Water)

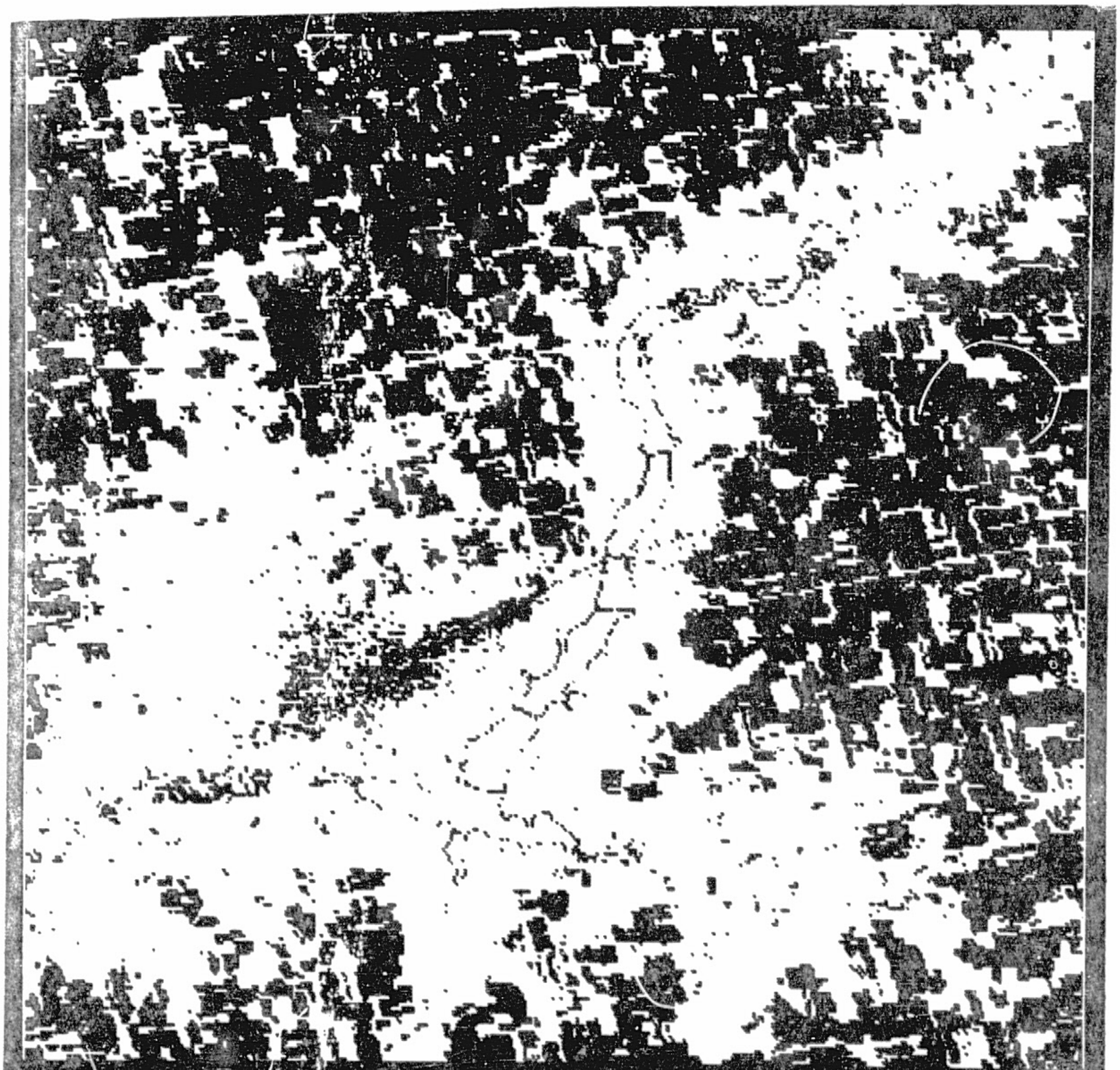


Figure 18c. Display of the White Classification (Bare Soil: Ploughed Fields, River Banks)

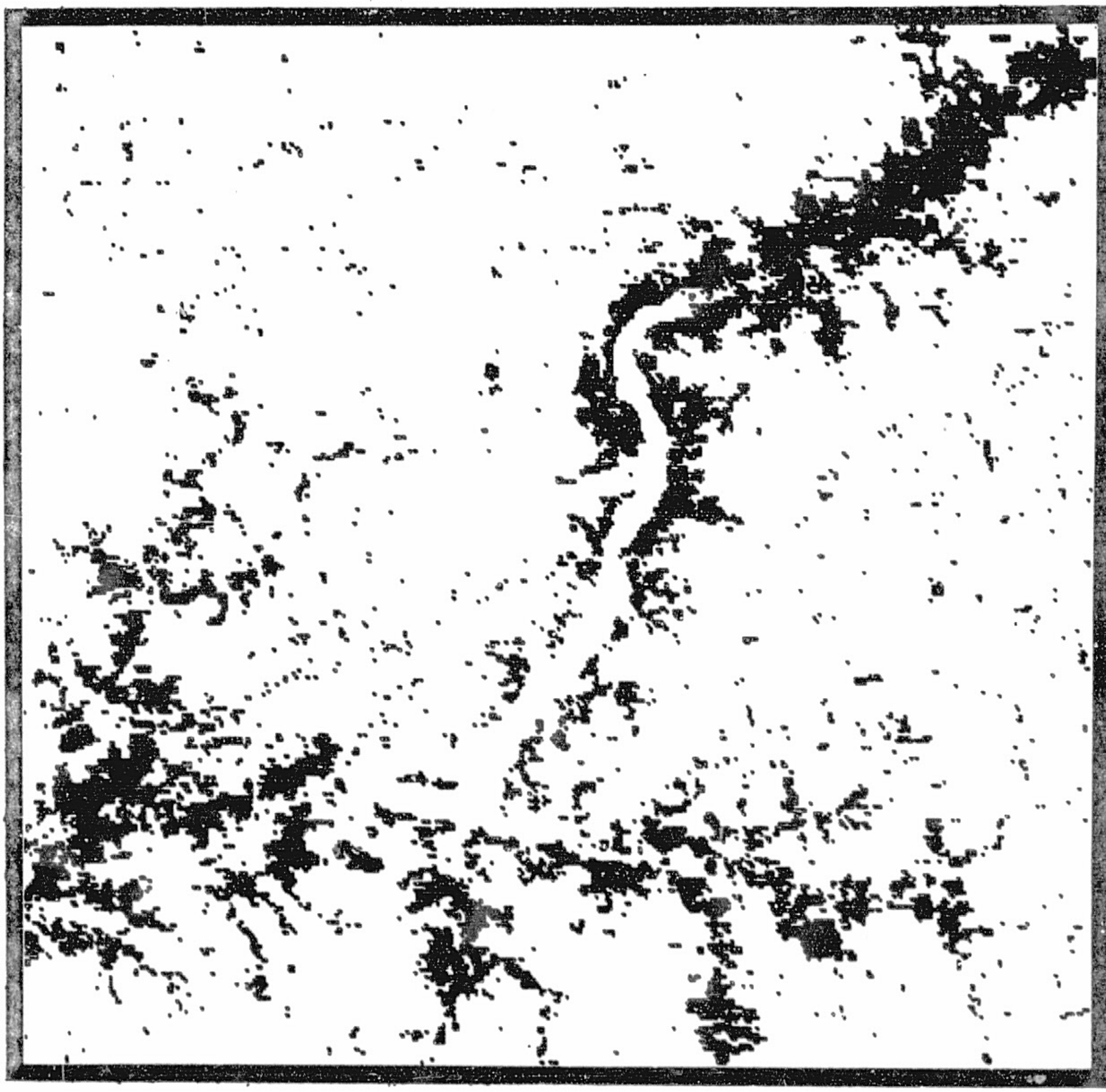


Figure 18d. Display of the Green Classification
(River Bottom Vegetation)

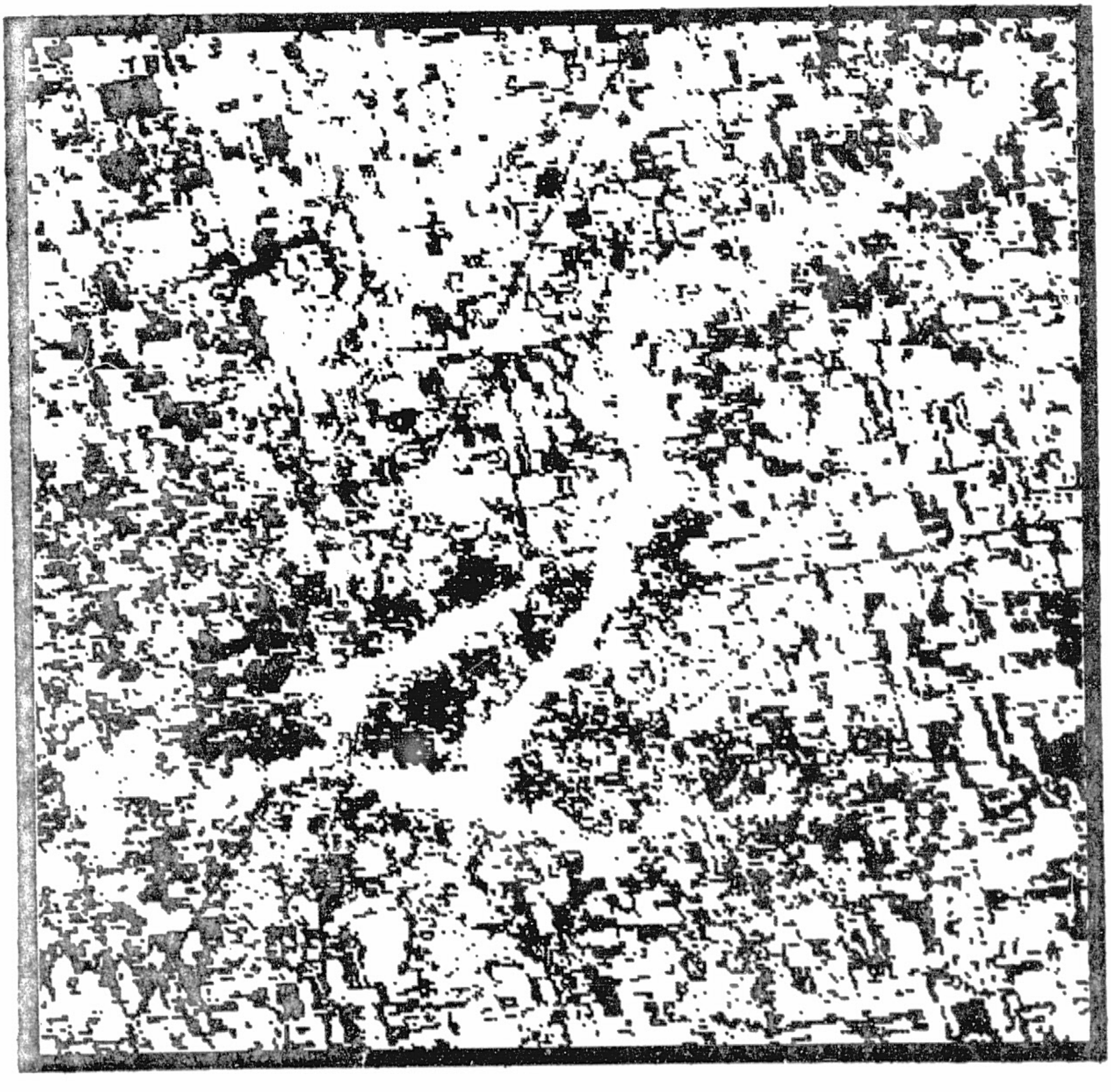


Figure 18e. Display of the Black Classification (Mixture of Vegetation and Residence and Bare Soil in Rural Areas)

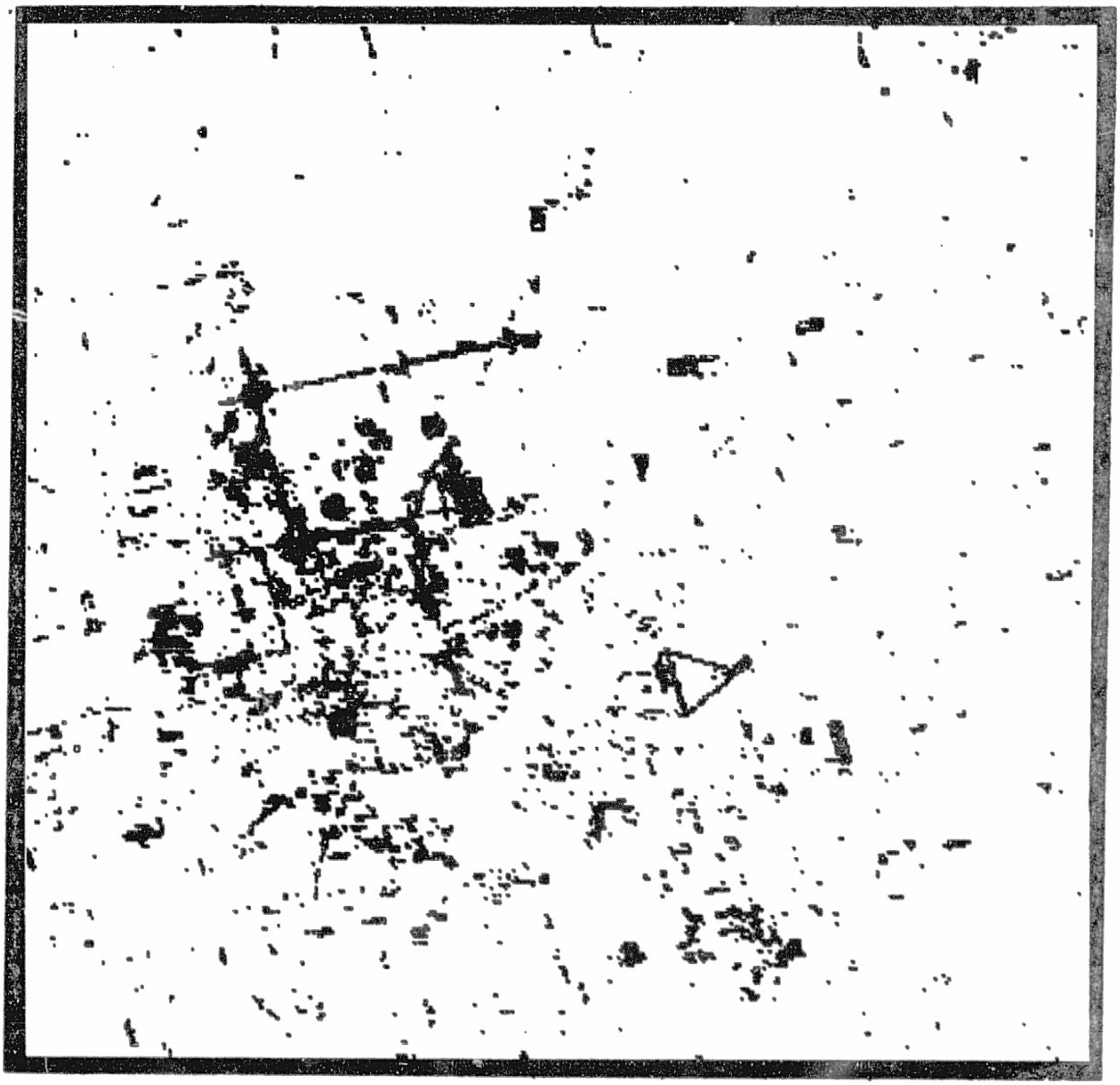


Figure 18f. Display of Red Classification (Concrete: Highways, Runways, Industrial)

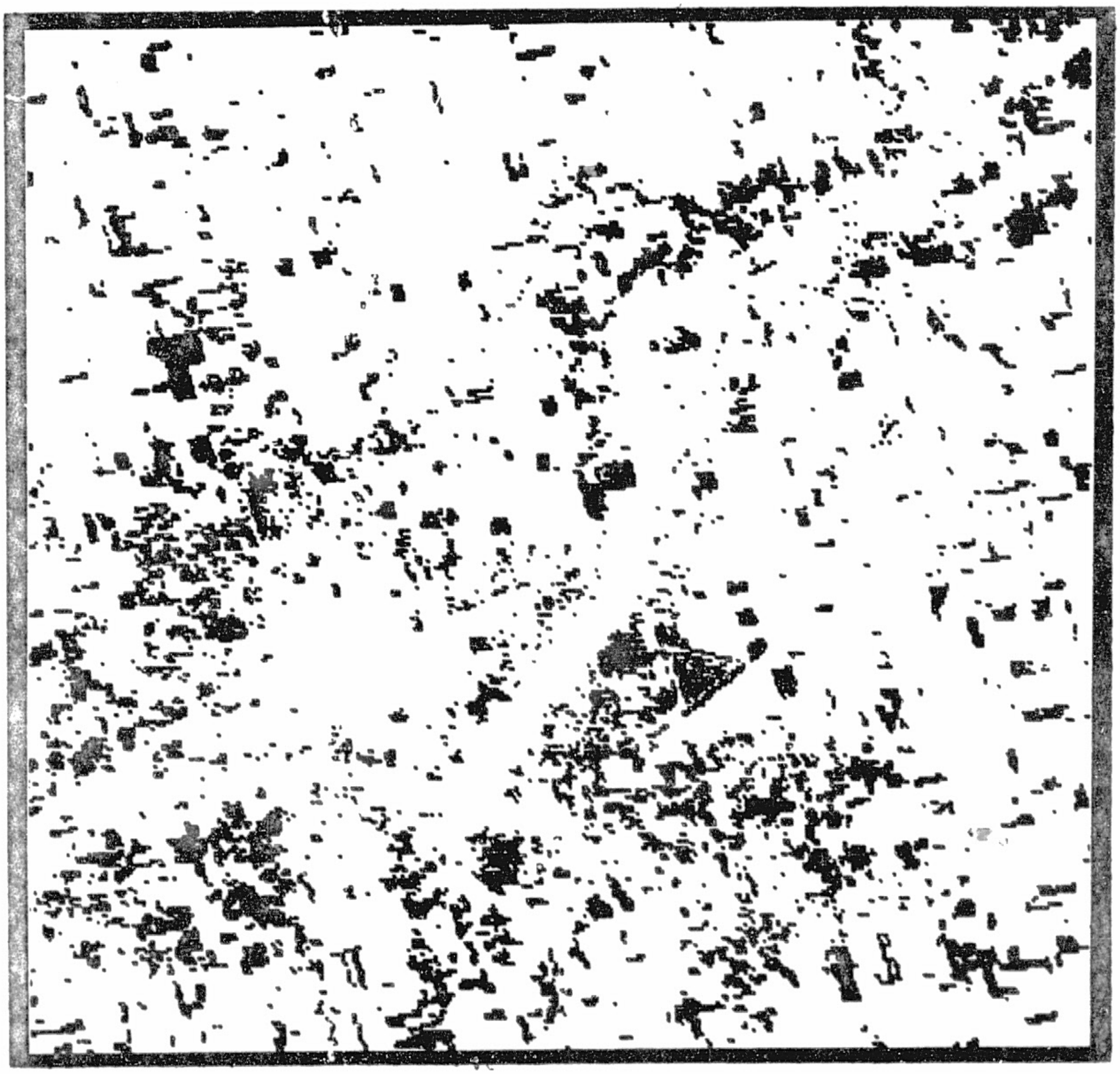


Figure 18g. Display of the Grey Classification (Drying Vegetation: Grasses and Stubble Fields)

Figures 18a, b, c, d, e, and f show the digital classification of the ERTS tape. Figure 18a is the color-coded composite of the classification. Each "class-at-a-time" display was generated by a line-plotter (Calcomp) and used as a paper negative to make a Diazo color positive. These were placed in register to obtain the color-coded classification.

The "class-at-a-time" display enables a much clearer comparison of the classification to underflight imagery or ground truth. In this experiment, six groupings appeared to match the manual digitized imagery well. Although some redundancy occurs in the manual interpretation, it is insignificant since three urban classes (Figure 16) can be combined into a single class and the in-water vegetation comprises such a small area. On the digital interpretation, this latter class (vegetation) is seen as part of the group reflecting open space and bare soil. This seems reasonable for an area which consists of a mixture of vegetation (high IR return) and water (little or no IR return). The manual interpretation can then be viewed as a classification consisting of essentially six classes.

Comparison of the two interpretations shows considerable similarity. The principal discrepancy is lack of continuity in the manually interpreted maps in comparison to the digital maps. Highways, airport runways, and interchanges are much more consistent on the digital maps. This is partly due to the small cell (pixell) size of the digital interpretation. The greater degree of spatial detail of the digital classification is of considerable advantage; however, the manual interpretation is detailed enough to be useful.

4 CONCLUSIONS

When considering the advantages of manual over digital interpretation, such as low cost, the input of the decision-making process by the interpreter, and the flexibility of the system to update and compare other maps, it may be concluded that an optical processing system can be effectively used to monitor small regions contained in an ERTS image. Figures 19 through 23 show the system's effectiveness in depicting seasonal variations.

A complete comparison between optical processing and machine processing techniques cannot be made without comparing the interpretations obtained from both methods to ground truth evaluations. This comparison will be made in a continuing study, using the Clarenance Cannon Reservoir in northeastern Missouri where construction has already begun. The Corps of Engineers has acquired extensive ground truth over the surrounding area, which will enable more realistic evaluation of the effectiveness of optical enhancement and manual interpretation techniques. The ongoing construction and eventual filling and operation of the reservoir will provide an excellent situation for change detection analysis.

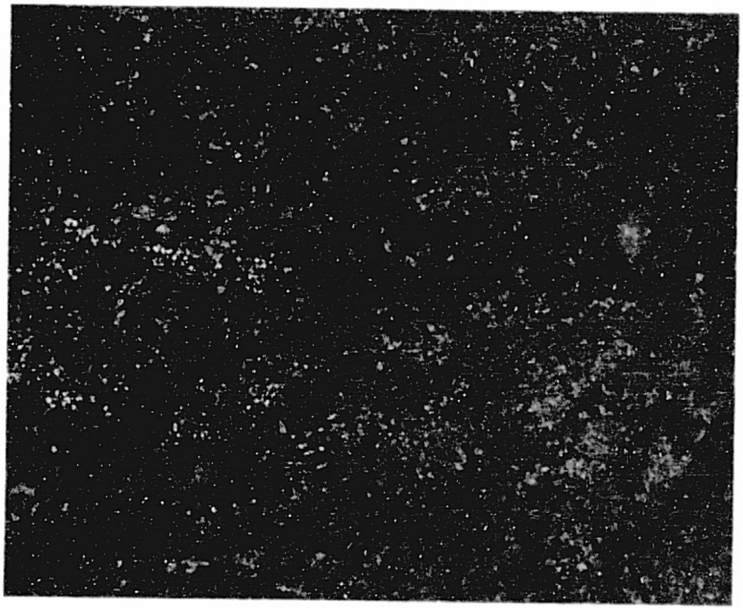


Figure 19. Portion of 23 February Color Composite (Map 4)

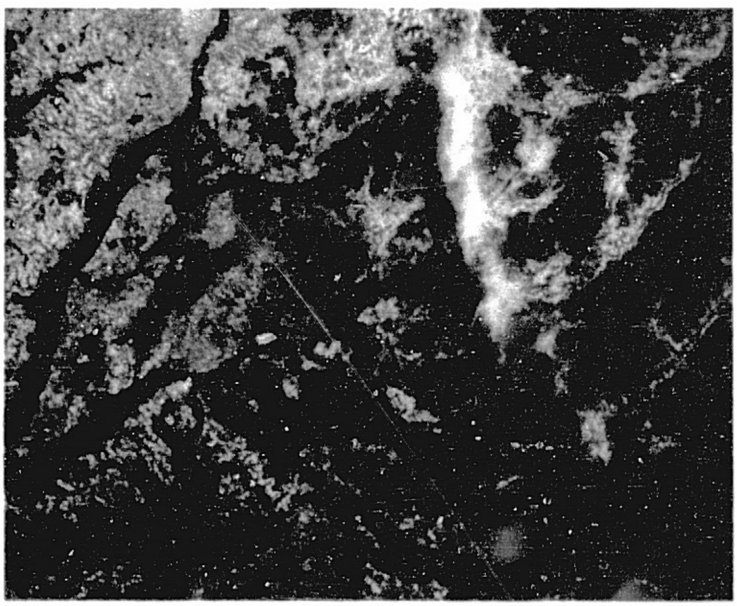


Figure 20. Portion of 24 May Color Composite (Map 4)

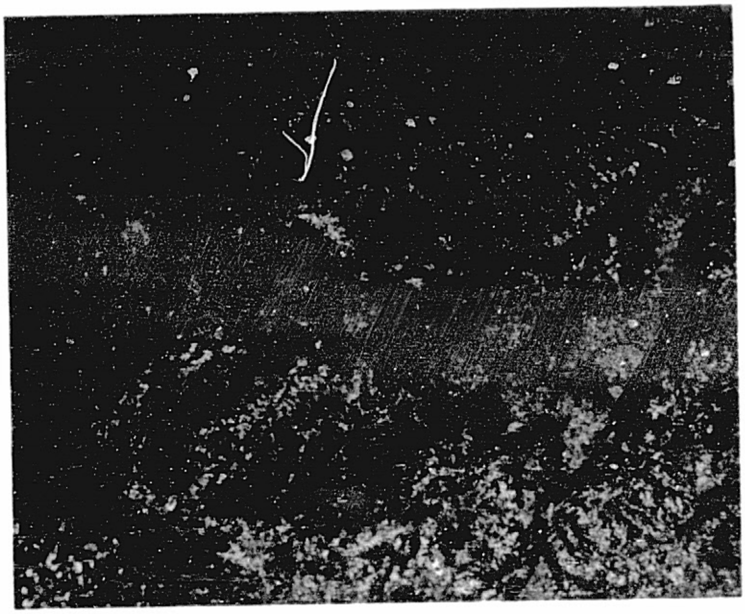


Figure 21. Portion of 11 June Color Composite (Map 4)

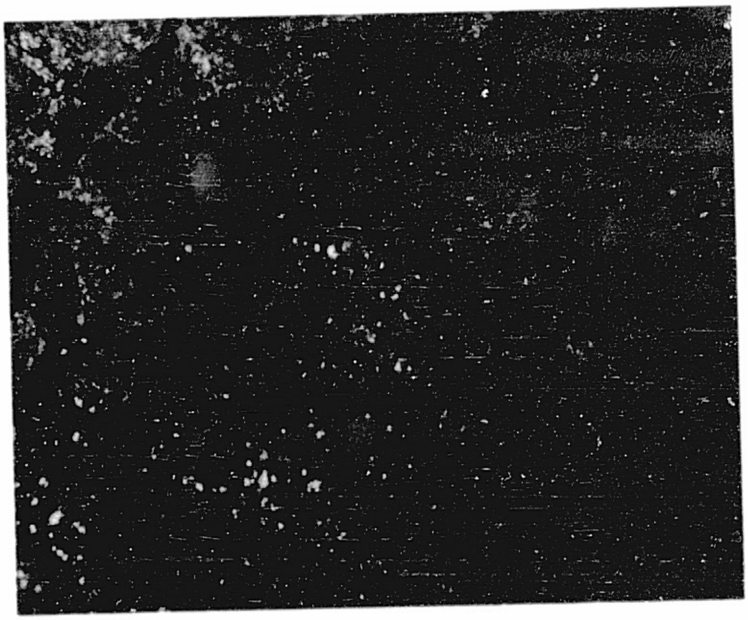


Figure 22. Portion of 21 August Color Composite (Map 4)

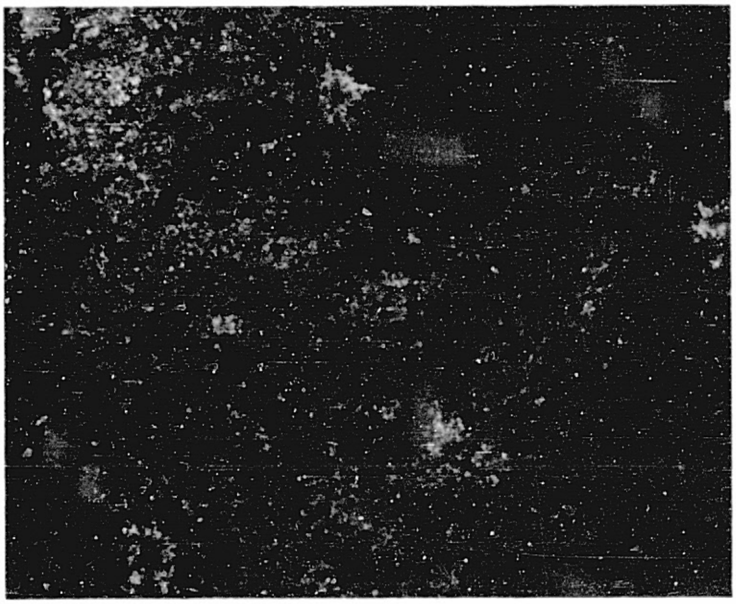


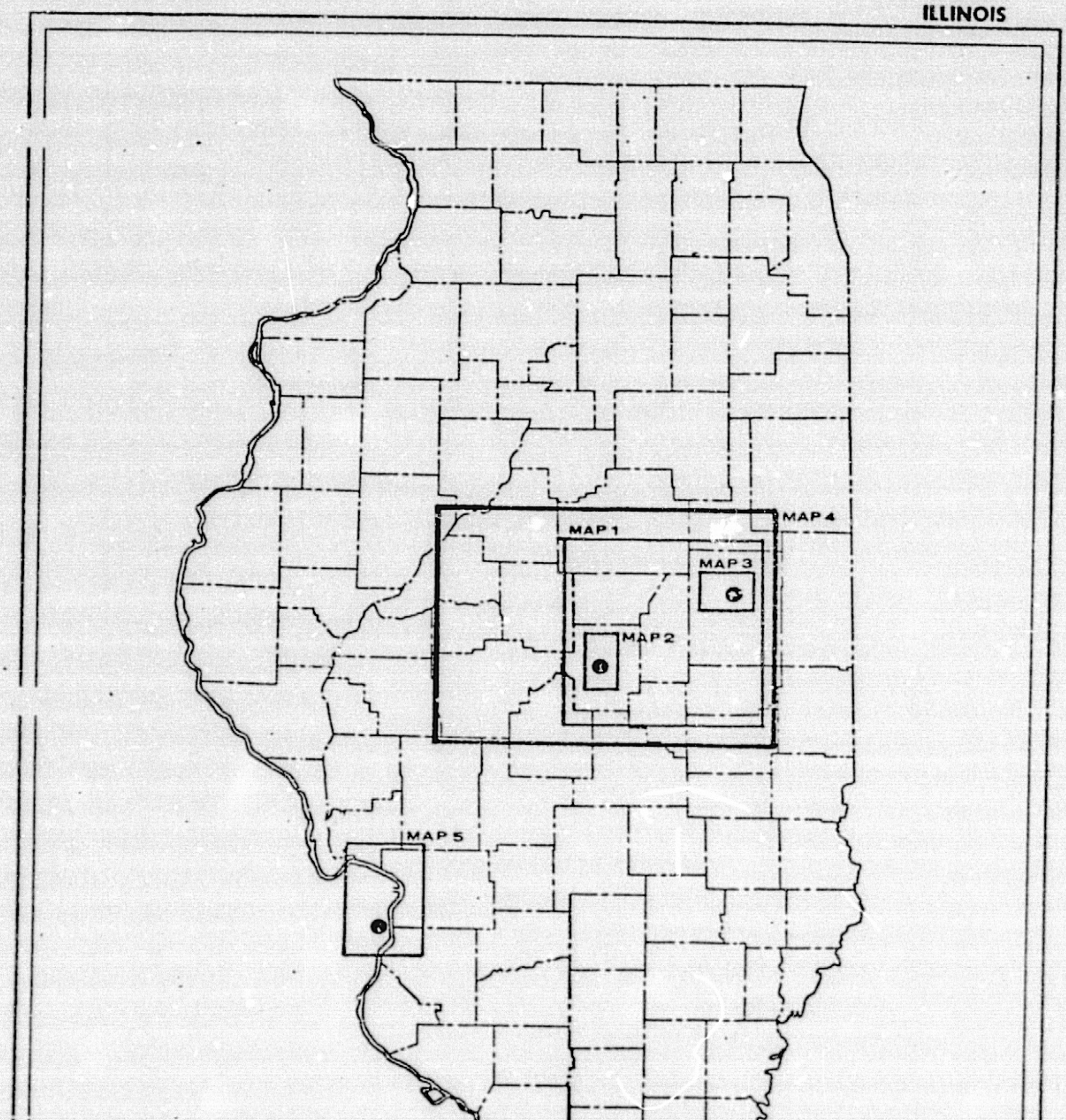
Figure 23. Portion of 2 October Color Composite (Map 4)

APPENDIX A

Generalized Areas in Illinois Corresponding to Image Coverage Contained in This Report

46

46


ILLINOIS
MAP 1
MAP 2
MAP 3
MAP 4
MAP 5
20 0 20 40 60
miles
Department of Geography, University of Illinois

APPENDIX B

Computer Program to Produce Calcomp-drawn Grid Sheets for Use in Throwback Projector Interpretation

```
      C         PROGRAM: TO PRODUCE CALCOMP DRAWN GRID SHEETS FOR USE IN
      C         THROW-BACK PROJECTOR INTERPRETATION
      C
      C         PROGRAMMER: PAUL TESSAR
      C         DEPT. OF URBAN PLANNING
      C         UNIVERSITY OF IILINOIS
      C         NOVEMBER,1973
      C
      C         INSTRUCTIONS: THE PROGRAM READS ONE CONTROL CARD TO PRODUCE ONE
      C         GRID SHEET. THIS CARD CAN BE REPEATED ANY NUMBER OF TIMES TO
      C         PRODUCE DIFFERENT GRID SHEETS.
      C
      C         CONTROL CARD
      C
      C         COLS  1-10 XCELL   NO. OF VERTICAL CELLS ON GRID
      C              11-20 XINCH   NO. OF VERTICAL CELLS PER INCH
      C              21-30 YCELL   NO. OF HORIZONTAL CELLS ON GRID
      C              31-40 YINCH   NO. OF HORIZONTAL CELLS PER INCH
      C
      C         EXAMPLE: FOR A GRID SHEET OF SIZE 8 INCHES HORIZONTALLY AND
      C         10 INCHES VERTICALLY WITH A CELL SIZE OF 1/10 OF AN INCH SQUARE,
      C         YCELL=80,YINCH=.1,XCELL=100,XINCH=.1.
      C
      C
0001            DIMENSION DIGIT(10)
0002            DATA DIGIT/1.,2.,3.,4.,5.,6.,7.,8.,9.,0./,IGRAPH,XBOT,YBOT/0,2*0./
0003            LOGICAL ODDX,ODDY
0004            CALL ZIP(10,64,9,9)
0005      1     READ (5,100,END=999)XCELL,XINCH,YCELL,YINCH,BC,XLET,XACC,YACC
0006    100     FORMAT (8F10.1)
0007            IF (XACC.EQ.0.) XACC=10.
0008            IF (YACC.EQ.0.) YACC=10.
0009            M=XACC/2.
0010            L=YACC/2.
0011            B=.08
0012            IF (XLET.NE.0.) B=XLET
0013            IGRAPH=IGRAPH+1
0014            WRITE (6,104) IGRAPH
0015    104     FORMAT ('-',/' ',16X,100('#'),/'0',61X,'GRAPH #',I3)
0016            WRITE (6,103) XCELL,XINCH,YCELL,YINCH
0017    103     FORMAT ('0GRAPH WILL HAVE', F8.0 ,'  VERTICAL  CELLS AT',F6.0 ,
               C ' CELLS PER INCH' / ' ',15X,F8.0, ' HORIZONTAL CELLS AT', F6.0,
               C ' CELLS PER INCH')
0018            XDISP=0.0
0019            YDISP=0.0
0020            YTOP=YCELL/YINCH
0021            XTOP=XCELL/XINCH
0022            XCELL=XCELL+1.
```

```
            YCELL=YCELL+1.
            NX=XCELL/2.
            NY=YCELL/2.
            XINCR=1./XINCH
            YINCR=1./YINCH
            A=XTOP+2.
            ODDX = IFIX(YCELL/2.)*2.NE.IFIX(YCELL)
            ODDY = IFIX(XCELL/2.)*2.NE.IFIX(XCELL)
            CALL PLOT( 3.,0.,-3)
            CALL PLOT (0.,.2,3)
            CALL OFFSET ( 0.,1.,-.2,1.)
            WRITE (6,105) XBOT,XTOP,XINCR,YBOT,YTOP,YINCR
      105   FORMAT ('0X-LINES WILL RUN FROM',F8.1,' TO',F8.1,5X,'INCR=',F8.3,/
           C        ' Y-LINES WILL RUN FROM',F8.1,' TO',F8.1,5X,'INCR=',F8.3)
C*****      DRAW COLUMNS  (PARRALLEL TO PAPER EDGE)
            CALL ACCX (XBOT,YDISP,XTOP)
            DO 50 IX=1,NY
               CALL PLOT(XTOP,YDISP,12)
               IF ((IX-1)/L*L.EQ.(IX-1))CALL ACCX(XTOP,YDISP,XBOT)
               YDISP=YDISP+YINCR
               CALL PLOT(XTOP,YDISP,13)
               CALL PLOT(XBOT,YDISP,12)
               YDISP=YDISP+YINCR
               CALL PLOT(XBOT,YDISP,13)
       50      CONTINUE
            IF (.NOT.ODDX) GO TO 200
            CALL PLOT(XTOP,YDISP,12)
            CALL ACCX(XTOP,YDISP,XBOT)
      200   CALL PLOT(XBOT,YBOT,13)
C*****      DRAW ROWS
            CALL ACCY(XDISP,YBOT,YTOP)
            DO 51 IY=1,NX
               CALL PLOT(XDISP,YTOP,12)
               IF ((IY-1)/M*M.EQ.(IY-1))CALL ACCY(XDISP,YTOP,YBOT)
               XDISP=XDISP+XINCR
               CALL PLOT(XDISP,YTOP,13)
               CALL PLOT(XDISP,YBOT,12)
               XDISP=XDISP+XINCR
               CALL PLOT(XDISP,YBOT,13)
       51      CONTINUE
            IF (.NOT.ODDY) GO TO 201
            CALL PLOT(XDISP,YTOP,12)
            CALL ACCY(XDISP,YTOP,YBOT)
      201   CALL PLOT(XBOT,YBOT,3)
C*****      WRITE IN SCALE NUMBERS ALONG VERTICAL AND HORIZONTAL AXES
            IY=YCELL-1.
            IX=XCELL-1.
            ITEN=(IX+10)/10
```

```
      IF (IX/10*10.EQ.IX) ITEN=IX/10
      Y1=0.
      DO 55 LL=1,2
      XDISP=0.23
      N=0
      IF (LL.EQ.2) ITEN=ITEN+1
      DO 53 I=1,ITEN
      DO 53 J=1,10
      N=N+1
      IF (N.GT.IX) GO TO 54
      CALL NUMBER(XDISP,Y1, B ,DIGIT(J),0.,-1)
      XDISP=XDISP+XINCR
   53 CONTINUE
   54 CONTINUE
      XDISP=0.03+9.*XINCR
      Y1=Y1+.1
      N=9
      ITEN=ITEN-1
      L=0
      DO 56 I=1,ITEN
      L=L+1
      IF (L.EQ.11) L=1
      DO 56 J=1,10
      N=N+1
      IF (N.GT.IX) GO TO 57
      CALL NUMBER(XDISP,Y1, B ,DIGIT(L),0.,-1)
      XDISP=XDISP+XINCR
   56 CONTINUE
   57 Y1=Y1+YTOP+.11
   55 CONTINUE
      ITEN=(IY+10)/10
      IF (IY/10*10.EQ.IY) ITEN=IY/10
      X1=-.04
      DO 65 LL=1,2
      IF (LL.EQ.2) ITEN=ITEN+1
      YDISP=0.23
      N=0
      DO 63 I=1,ITEN
      DO 63 J=1,10
      N=N+1
      IF (N.GT.IY) GO TO 64
      CALL  NUMBER ( X1 ,YDISP, B , DIGIT(J),90.,-1)
     1   YDISP=YDISP+YINCR
   63 CONTINUE
   64 CONTINUE
      YDISP=0.23+9.*YINCR
      X1=X1-.1
      N=9
```

```
                                                                                    00001350
0115                 ITEM=ITEN-1                                                    00001355
0116                 L=0                                                            00001360
0117                 DO 66 I=1,ITEN                                                 00001365
0118                 L=L+1                                                          00001370
0119                 IF (L.EQ.11) L=1                                               00001375
0120                 DO 66 J=1,10                                                   00001380
0121                 N=N+1                                                          00001385
0122                 IF (N.GT.IY) GO TO 67                                          00001390
0123                 CALL  NUMBER ( X1 ,YDISP, B , DIGIT(L),90.,-1)                 00001395
0124                    YDISP=YDISP-YINCR                                           00001400
0125          66     CONTINUE                                                       00001405
0126          67     X1=XTOP+1.*ABS(X1) -.21                                        00001410
0127          65     CONTINUE                                                       00001415
0128                 CALL PLOT( A ,0.,-3)                                           00001420
0129                 CALL CCP1BA                                                    00001425
0130                 GO TO 1                                                        00001430
0131         999     CONTINUE                                                       00001435
0132                 CALL EXCOR2(IEX)                                               00001440
0133                 IEX=IEX-10                                                     00001445
0134                 WRITE (6,101) IEX                                              00001450
0135         101     FORMAT ('-',132('*'),/'-',40X,'ALL GRAPHS HAVE BEEN PLOTTED',/'0',00001455
                    C40X,I3,'K BYTES OF CORE WERE NOT USED IN THIS RUN')            00001460
0136                 STOP                                                           00001465
0137                 END
```

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
ZIP	144	IBCOM#	148	PLOT	14C	OFFSET	150	ACCX	154
ACCY	158	NUMBER	15C	CCP1BA	160	EXCOR2	164		

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IGRAPH	2FC	XBOT	300	YBOT	304	XCELL	308	XINCH	30C
YCELL	310	YINCH	314	BC	318	XLET	31C	XACC	320
YACC	324	H	328	L	32C	B	330	XDISP	334
YDISP	338	YTOP	33C	XTOP	340	NX	344	NY	348
XINCR	34C	YINCR	350	A	354	ODDX	358	ODDY	35C
IX	360	IY	364	ITEN	368	Y1	36C	LL	370
N	374	I	378	J	37C	X1	380	IEX	384

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
DIGIT	388								

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
100	390	104	387	103	309	105	440	101	4AE

STATEMENT NUMBER MAP

STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION
2	508	4	5D8	5	5F2	7	65C	8	652
9	668	10	68E	11	654	12	6BC	13	6D2
14	6DF	16	6FC	18	730	19	738	20	740
21	74C	22	758	23	764	24	770	25	796
26	79C	27	7C8	28	7D4	29	7E0	30	836
31	84C	32	896	33	840	34	8AA	36	8F0
37	8FA	38	902	39	90C	40	93A	41	946
42	950	43	95A	44	966	45	970	46	984
47	990	48	99A	49	9A4	50	9AE	51	988
52	9C[illegible]	53	9CA	54	9F8	55	A04	56	A0E
57	A18	58	A24	59	A2E	60	A42	61	A4E
62	A58	63	A62	64	A6C	65	A92	66	A88
67	[illegible]	68	AF6	69	AFE	70	B06	71	B0E
72	B16	73	B30	74	B38	75	B44	76	B50
77	95F	78	B70	79	B7C	80	BA8	81	BA8
82	[illegible]	83	BC4	84	BCC	85	BD8	86	BE0
87	BE8	88	BF4	89	C0A	90	C12	91	C1E
92	C2[illegible]	93	C46	94	C52	95	C7A	96	C8A
97	C9E	98	C92	99	CDC	100	CE4	101	CEC
102	D[illegible]6	103	D0E	104	D16	105	D1E	106	D2A
107	D36	108	D44	109	D56	110	D62	111	D8E
112	D8F	113	D9E	114	DAA	115	D82	116	DBE
117	DC6	118	DCE	119	DDA	120	DF0	121	DF8
122	E04	123	E12	124	E2C	125	E38	126	E60
127	E7[illegible]	128	E8A	129	E94	130	E9E	131	EA4
132	[illegible]	133	EAE	134	EBA	136	ED8		

```
*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,MAP
*OPTIONS IN EFFECT*  NAME = MAIN     , LINECNT =       50
*STATISTICS*     SOURCE STATEMENTS =       137,PROGRAM SIZE =      3814
*STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
FORTRAN IV G LEVEL  21                ACCX              DATE = 75058          23/31/05          PAGE 0001

0001                SUBROUTINE ACCX(X,Y,Z)                                           00001470
0002                Y1=Y-.0075                                                       00001475
0003                Y2=Y+.0075                                                       00001480
0004                CALL PLOT(X,Y1,12)                                               00001485
0005                CALL PLOT(Z,Y1,12)                                               00001490
0006                CALL PLOT(Z,Y2,12)                                               00001495
0007                CALL PLOT(X,Y2,12)                                               00001500
0008                CALL PLOT(X,Y,12)                                                00001505
0009                RETURN                                                           00001510
0010                ENTRY ACCY(X,Y,Z)                                                00001515
0011                X1=X-.0075                                                       00001520
0012                X2=X+.0075                                                       00001525
0013                CALL PLOT(X1,Y,12)                                               00001530
0014                CALL PLOT(X1,Z,12)                                               00001535
0015                CALL PLOT (X2,Z,12)                                              00001540
0016                CALL PLOT (X2,Y,12)                                              00001545
0017                CALL PLOT(X,Y,12)                                                00001550
0018                RETURN                                                           00001555
0019                END                                                              00001560
```

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
PLOT	98								

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
Y1	134	Y	138	Y2	13C	X	140	Z	144
X1	148	X2	14C						

STATEMENT NUMBER MAP

STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION
1	258	2	258	3	264	4	270	5	27A
6	284	7	28E	8	298	9	2A2	10	2AA
11	2A4	12	2B6	13	2C2	14	2CC	15	2D6
16	2E0	17	2EA	18	2F4				

```
*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,MAP
*OPTIONS IN EFFECT*  NAME = ACCX      , LINECNT =       50
*STATISTICS*    SOURCE STATEMENTS =         19,PROGRAM SIZE =        764
*STATISTICS*  NO DIAGNOSTICS GENERATED

*STATISTICS*  NO DIAGNOSTICS THIS STEP
```

OS/360 LOADER (UOI VERSION 1.1)

OPTIONS USED - PRINT,MAP,NOLET,CALL,NORES,NOTERM,SIZE=108544,NAME=**GO

NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR
MAIN	SD	65010	ACCX	SD	65EF8	ACCY	LR	65F28	EXCORZ *	SD	661F8	CCP1BA *	SD	66250
ZIP *	LR	6626A	NUMBER *	SD	66338	CCP3NR *	LR	66338	CCP1OS *	SD	66480	OFFSET *	LR	66480
PLOTS *	SD	66520	CCP1PS *	LR	66520	CCP1IZ *	LR	66520	ORGNSE *	LR	66520	CCP1 *	SD	66528
PLOT *	LR	666F0	CCP1PL *	LR	666F0	IHCECOMH *	SD	66960	IBCOM# *	LR	66860	FDIOCS# *	LR	66C1C
INTSWTCH *	LR	67AB6	IHCCOMH2 *	SD	67AA8	SEQDASD *	LR	680E4	IHCETRCH *	SD	683[illegible]	IHCTRCH *	LR	68300
ERRTRA *	LR	68302	[illegible] *	LR	68918	DMPLST# *	LR	68970	BRITH# *	SD	68A[illegible]	REGS# *	LR	68A54
[illegible] *	SD	[illegible]	ERRMON *	LR	68AA0	IHCERRE *	LR	[illegible]88	IHCUOPT *	SD	69080	IHC[illegible]ENTH *	SD	69300
ARITH# *	LR	69300	ADJSWTCH *	LR	6975C	IHCEFIOS *	SD	69918	FIOCS# *	LR	69918	FIOCSBEP *	LR	6991E
IHC[illegible]2 *	SD	6A840	IHCFCVTH *	SD	6AD70	ADCON# *	LR	6AD70	FCVAOUTP *	LR	6AE1A	FCVLOUTP *	LR	6AEAA
FCVZOUTP *	LR	6[illegible]	FCVIOUTP *	LR	6B3A8	FCVEOUTP *	LR	6B8AA	FCVCOUTP *	LR	6B4[illegible]4	INT6SWCH *	LR	6BDA8
CCPSYSPT *	SD	6BF10	CCPSYSSV *	SD	6C080	CCPSYSLD *	LR	6C0F8	CCPERZ *	SD	6C168	SYMBOL *	SD	6C100
CCP2SY *	LR	6C1[illegible]0	CCP2SB *	LR	6C1D0	TELSYM *	SD	6CAA8	IHCSSCN *	SD	6CAB0	COS *	LR	6CA80
SIN *	LR	6CAC8	CCP1PP *	SD	6CC90	WHERE *	LR	6CC9C	UISYSERR *	SD	6D008	SYSERR *	LR	6D008
IHCUATBL *	SD	6CE50												

TOTAL LENGTH 8478
ENTRY ADDRESS 65010

```
UTFPROC4    PROTECTION                                       PSW=FF8500000206C15A

TRACEBACK     (MAIN PGM. AT LOC.  065010)
              MAIN      EXECUTED CALL FROM DISPLACEMENT    0005E2
              (066264) FAILED AT DISPLACEMENT    005EF0
END OF TRACEBACK

REGISTERS:
 FF000003  00065178  00065504  000655C8  00081640  FFFFFFFF  00081758  000000FF
 00065178  00000000  00060418  00065000  4206627C  00060080  42066290  8001347C
```

APPENDIX C

Computer Program Listing and Output from
Color-coded Grid Interpretation (Figure 15)

```
C      PROGRAM: GRBX-MAP
C
C      PURPOSE: COMPUTER MAPPING PROGRAM FOR USE WITH GRIDDED
C      INTERPRETATION SHEETS AND THROWBACK PROJECTION SYSTEM.
C
C      PROGRAMMER: J.RONALD EYTON
C                  GEOGRAPHY DEPT.
C                  UNIVERSITY OF ILLINOIS
C                  JANUARY 1974
C
C      INSTRUCTIONS: PROGRAM READS 2 OR 3 CONTROL CARDS AND THEN DATA
C      CARDS. I=INTEGER VALUE,FP=FLOATING POINT VALUE.
C
C      CONTROL CARD 1: TITLE CARD
C      COLS 1-80 ANY DESIRED TITLE
C
C      CONTROL CARD 2: MAP CARD
C      COLS 1-3 NROWS NUMBER OF ROWS ON GRID SHEET (I)
C      COLS 10-12 NCOLS NUMBER OF COLUMNS ON GRID SHEET (I)
C      COL 20 NCAT IS ONE CLASS AT A TIME DISPLAY DESIRED? (I)
C      0=NO,1=YES
C      COLS 30-39 SCALE LARGER VALUEOF AN RF SCALE OF GRID SHEET (FP)
C      COLS 40-41 NCLASS NUMBER OF CLASSES (I)
C      COL 52 LINPR NUMBER OF ROWS PER INCH ON GRID SHEET (I)
C      COL 60 NCLTYP CLASS DESIGNATION (I)
C      1=NUMERALS,2=LETTERS
C
C      CONTROL CARD 3: USE ONLY IF NCLTYP OF PREVIOUS CARD=2. THIS
C      CARD INDICATES THAT LETTERS WILL BE USED TO INDICATE CLASSES.
C      UP TO 9 CLASSES ARE ALLOWED AS WITH THE NUMERIC INDICATION
C      OF CLASSES IF GREY LEVEL MAPS (OVERPRINTING) ARE DESIRED.
C      IF A GREATER NUMBER OF CLASSES IS DESIRED ,THE USER CAN
C      ENTER UP TO 20 LETTERS OR SYMBOLS. HOWEVER THE MAP WILL BE
C      PRINTED USING THESE SYMBOLS ONLY. STARTING IN COLUMN ONE PUNCH
C      THE LETTER OR SYMBOL REPRESENTING THE FIRST CLASS,IN COLUMN TWO
C      PUNCH THE LETTER OR SYMBOL REPRESENTING THE SECOND CLASS AND SO
C      ON UNTIL ALL CLASSES HAVE BEEN DESIGNATED.
C
C
       DIMENSION ID(20),NCOD(100,80),MAP1(82),MAP2(82),MAP3(82)
       DIMENSION ISX1(10),ISX2(10),ISX3(10),NCOUNT(21),MID(21)
       DATA MINUS/'-'/,MID(21)/' '/
       DATA ISX1/'.',':','=','+','C','(','O','O','O','C',' '/
       DATA ISX2/' ',' ',' ',' ',' ','-','X','*','*',' '/
       DATA ISX3/' ',' ',' ',' ','-',' ',' ',' ','X',' '/
       DATA NSLASH/'/'/
       READ(5,11)(ID(J),J=1,20)
```

```
      11 FORMAT(20A4)
         READ(5,21) NROWS,NCOLS,NCAT,SCALE,NCLASS,LINPR,NCLTYP
      21 FORMAT(I3,6X,I3,7X,I1,9X,F10.1,I2,8X,I1,9X,I1)
         IF(NCLTYP.NE.2) GO TO 30
         READ(5,24)(MID(J),J=1,NCLASS)
      24 FORMAT(20A1)
         WRITE(6,31)(ID(J),J=1,20)
         WRITE(6,32) NROWS,NCOLS,NCAT,SCALE,NCLASS,LINPR,NCLTYP
         WRITE(6,33)(MID(J),J=1,20)
      31 FORMAT('1',20A4,//)
      32 FORMAT(1X,'NROWS= ',I3,',NCOLS= ',I3,',NCAT= ',I1,',SCALE= ',F10.1
        *,//1X,'NCLASS= ',I2,',LINPRV ',I1,',NCLTYP= ',I1,//)
      33 FORMAT(1X,'CLASS SYMBOLS USED:',20(A1,1X),//)
         WRITE(6,34)
      34 FORMAT(1X,'CARD NO.',5X,'|**************************************CARD-V
        *ALUES**************************************|',/)
      30 DO 50 K=1,NROWS
         READ(5,51)(NCOD(K,J),J=1,NCOLS)
      51 FORMAT(80A1)
         WRITE(6,35) K,(NCOD(K,J),J=1,80)
      35 FORMAT(3X,I3,4X,80A1,/)
         IF(NCLTYP.NE.2) GO TO 56
         DO 55 J=1,NCOLS
         IF(NCOD(K,J).NE.ISX1(10)) GO TO 53
         NCOD(K,J)=0
         GO TO 55
      53 DO 52 I=1,NCLASS
         IF(NCOD(K,J).EQ.MID(I)) GO TO 54
      52 CONTINUE
      54 NCOD(K,J)=I
      55 CONTINUE
      56 DO 20 J=2,80
         KK=J-1
      20 IF(NCOD(K,J).EQ.0) NCOD(K,J)=NCOD(K,KK)
      50 CONTINUE
         NN=1
         IF(NCAT.GE.1) NN=NCLASS+1
         DO 100 K=1,NN
         KJ=K-1
         WRITE(6,101)(ID(J),J=1,20)
     101 FORMAT('1',26X,20A4,/////)
         IF(K.EQ.1) GO TO 103
         WRITE(6,102) KJ
     102 FORMAT(58X,'CLASS ',I2,' DISPLAYED',//////)
         GO TO 105
     103 WRITE(6,104)
     104 FORMAT(56X,'ALL CLASSES DISPLAYED',//////)
     105 WRITE(6,106)(MINUS,J=1,NCOLS)
```

```
 106 FORMAT(26X,80A1)
     DO 107 LL=1,10
 107 NCOUNT(LL)=0
     DO 110 KK=1,NROWS
     DO 111 J1=1,82
     MAP1(J1)=ISX1(10)
     MAP2(J1)=ISX2(10)
 111 MAP3(J1)=ISX3(10)
     NM=NCOLS+1
     DO 130 JJ=2,NM
     JN=JJ-1
     L=[illegible](KK,JN)
     IF(K.[illegible].1) GO TO 120
     IF(NCLASS.LE.9.AND.L.NE.KJ) L=10
     IF(NCLASS.GE.1[illegible].AND.L.NE.KJ) L=21
 120 NCOUNT(L)=NCOUNT(L)+1
     IF(NCLASS.GT.9) GO TO 129
     MAP1(JJ)=ISX1(L)
     MAP2(JJ)=ISX2(L)
     MAP3(JJ)=ISX3(L)
     GO TO 130
 129 MAP1(JJ)=MID(L)
 130 CONTINUE
     MAP1(1)=NSLASH
     MAP1(NCOLS+2)=NSLASH
     WRITE(6,131)(MAP1(J),J=1,82)
     IF(NCLASS.GT.9) GO TO 110
     WRITE(6,132)(MAP2(J),J=1,82)
     WRITE(6,132)(MAP3(J),J=1,82)
 110 CONTINUE
 131 FORMAT(25X,82A1)
 132 FORMAT('+',24X,82A1)
     WRITE(6,108)(N(NOS,J),J=1,NCOLS)
 108 FORMAT(26X,80A1,//////)
     IF(N.GT.1) GO TO 99
     TOTFRE=0.
     DO 150 J=1,NCLASS
 150 TOTFRE=TOTFRE+NCOUNT(J)
     TOTAR=(NCOLS*NROWS*SCALE**2)/((5280.*120.*LINPR)**2)
  99 IF(N.EQ.1) NC=NCLASS
     IF(N.GT.1) NC=1
     CALL TABLE(NC,NCOUNT,KJ,ISX1,ISX2,ISX3,TOTFRE,TOTAR,NCLASS,MID)
 100 CONTINUE
     STOP
     END
```

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IRCOV*	188	CABLE	18C						

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
MINUS	198	NSLASH	19C	J	1C0	NROWS	1C4	NCOLS	1C8
NCAT	1CC	SCALE	1D0	NCLASS	1D4	LINPR	1D8	NCLTYP	1DC
K	1E0	I	1E4	KK	1E8	NN	1EC	KJ	1F0
LL	1F4	J1	1F8	NH	1FC	JJ	200	JN	204
L	208	TOTFRE	20C	TOTAR	210	NC	214		

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IO	218	NEED	268	MAP1	7F60	MAP2	8080	MAP3	81F8
ISX1	8340	ISX2	8368	ISX3	8390	NCOUNT	83B8	MID	840C

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
11	8457	21	8456	24	8481	31	8487	32	8492
33	84F0	34	8512	51	8574	35	857A	101	8587
105	8596	104	85B5	106	85D5	131	85DD	132	85E5
108	85FD								

STATEMENT NUMBER MAP

STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION	STATEMENT	LOCATION
3	[illegible]	4	86AC	5	86AC	6	86AC	7	86AC
8	86AC	10	86F0	12	873C	13	874E	15	8794
16	87D8	17	8824	21	886C	23	888D	24	8898
26	[illegible]	28	8948	29	895A	30	8968	31	8976
32	8982	33	8998	34	899A	35	89A6	36	89C2
37	89CA	38	89E6	39	89F4	40	8A04	41	8A48
42	8A70	43	8A7C	44	8A96	45	8AA2	46	8A92
48	8AF6	49	8B06	51	8B24	52	8B2A	54	8B40
56	[illegible]	57	8B8C	58	8BA0	59	8BC4	60	8BE0
61	[illegible]	62	8BF0	63	8C14	64	8C24	65	8C38
66	[illegible]	67	8C62	68	8C70	69	8CAA	70	8CE8
71	8C00	72	8D0E	73	8D16	74	8D1E	75	8D26
76	[illegible]	77	8D40	78	8D5C	79	8D6C	80	8D7C
81	[illegible]	82	8DD6	83	8E1C	84	8E64	87	8E88
86	[illegible]	90	8ED6	91	8EDE	92	8EEA	93	8F2A
94	8F34	95	8F9E	96	8FB8	97	8FC2	98	8FD6

OPTIONS IN EFFECT NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,MAP

```
FORTRAN IV G LEVEL  21                MAIN              DATE = 75058         10/39/38          PAGE 0005
  *OPTIONS IN EFFECT*  NAME = MAIN    , LINECNT =       50
  *STATISTICS*     SOURCE STATEMENTS =       99,PROGRAM SIZE =     36836
  *STATISTICS*  NO DIAGNOSTICS GENERATED
```

```
      SUBROUTINE CABLE(NC,NCOUNT,KJ,ISX1,ISX2,ISX3,TOTFRE,TOTAR,NCLASS,M
     *ID)
      DIMENSION NCOUNT(1),ISX1(1),ISX2(1),ISX3(1),MID(1)
      WRITE(6,11)
   11 FORMAT(33X,'CLASS',5X,'SYMBOL',5X,'FREQUENCY',5X,'AREA(SQ MI)',5X,
     *'AREA(P.C.)',//)
      DO 10 J=1,NC
      IF(NC.GT.1) KJ=J
      IF(NCLASS.GT.9) GO TO 12
      I1=ISX1(KJ)
      I2=ISX2(KJ)
      I3=ISX3(KJ)
      GO TO 13
   12 I1=MID(1)
      I2=MID(2)
      I3=MID(3)
   13 COUNT=NCOUNT(KJ)
      RAREA=COUNT/TOTFRE*100.
      AREA=(RAREA*TOTAR)/100.
      DO 40 K=1,3
      WRITE(6,101) I1,I1,I1
      IF(K.EQ.2) GO TO 30
      WRITE(6,102) I2,I2,I2
   20 WRITE(6,102) I3,I3,I3
      GO TO 40
   30 WRITE(6,103) KJ,I2,I2,I2,NCOUNT(KJ),AREA,RAREA
      GO TO 20
   40 CONTINUE
      WRITE(6,104)
  104 FORMAT(1X,/)
   10 CONTINUE
      ITOTFRE=TOTFRE
      WRITE(6,105) ITOTFRE,TOTAR
  105 FORMAT(56X,I5,9X,F7.2)
  101 FORMAT(44X,3A1)
  102 FORMAT('+',43X,3A1)
  103 FORMAT('+',34X,I1,8X,3A1,9X,I5,9X,F7.2,8X,F5.1)
      RETURN
      END
```

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IBCOM#	CC								

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION

```
J                 D0     NC          D4     KJ          D8     NCLASS      DC     I1        E0
I2                E4     I3          E8     CCUNT       EC     RAREA       F0     TOTFRE    F4
AREA              F8     TOTAR       FC     K           100    IOTFRE      104

                                      ARRAY MAP
SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION
NCOUNT       108       ISX1         10C       ISX2         110       ISX3         114       MID          118

                               FORMAT STATEMENT MAP
SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION     SYMBOL    LOCATION
   11        11A          104       150          105       162          101       160          102       175
  103        189

                               STATEMENT NUMBER MAP
STATEMENT LOCATION     STATEMENT LOCATION     STATEMENT LOCATION     STATEMENT LOCATION     STATEMENT LOCATION
    1        2?4           3        284           5        2C8           6        2D8           7        2EE
    8        2FC           9        314          10        320          11        32C          12        332
   13        344          14        352          15        35A          16        38A          17        39A
   18        34?          19        3B2          20        3E0          21        3EE          22        41C
   23        448          24        44E          25        44C          26        482          27        4C6
   29        4FC          30        4F0          31        510          36        534

*OPTIONS IN EFFECT*  NOID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,MAP
*OPTIONS IN EFFECT*  NAME = CABLE   , LINECNT =      50
*STATISTICS*    SOURCE STATEMENTS =       37,PROGRAM SIZE =     1340
*STATISTICS*  NO DIAGNOSTICS GENERATED

*STATISTICS*  NO DIAGNOSTICS THIS STEP
```

OS/360 LOADER (UCI VERSION 1.1)

OPTIONS USED - PRINT,MAP,NOLET,CALL,NORES,NOTERM,SIZE=108544,NAME=**GO

NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR	NAME	TYPE	ADDR
MAIN	SD	77010	CARLE	SD	7FFF8	IHCECOMH*	SD	80538	IBCOM# *	LR	80538	FDIOCS# *	LR	835F4
INTSWTCH*	LR	8145C	IHCCOMH2*	SD	81460	SEQDASD *	LR	81A0C	IHCETRCH*	SD	81DA8	IHCTRCH *	LR	81DA8
ERRTRA *	LR	[illegible]	[illegible] *	LR	822F0	DMPLST# *	LR	822F8	BRITH# *	SD	82408	REGS# *	LR	8242[illegible]
IHCERRM *	SD	82478	ERRMON *	LR	82478	IHCERRE *	LR	82490	IHCUOPT *	SD	82A58	IHCEFNTH*	SD	820[illegible]8
ARITH# *	LR	820[illegible]8	ADJSWTCH*	LR	83144	IHCEFIOS*	SD	832F0	FIOCS# *	LR	832F0	FIOCSBEP*	LR	832F6
IHCFIOS2*	SD	84218	IHCFCVTH*	SD	84748	ADCON# *	LR	84748	FCVAOUTP*	LR	847F2	FCVLOUTP*	LR	[illegible]4882
FCVZOUTP*	LR	84902	FCVIOUTP*	LR	84080	FCVEOUTP*	LR	85282	FCVCOUTP*	LR	8549C	INT6SWCH*	LR	85783
IHCUATBL*	SD	856E8												

TOTAL LENGTH FF10
ENTRY ADDRESS 77010

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE

```
NROWS=  96,NCOLS=  80,NCAT= 1,SCALE=    63360.0
NCLASS=  9,LINPRV 8,NCLTYP= 2

CLASS SYMBOLS USED    Y P A G K O N R

CARD NO.      |**********************************CARD-VALUES**********************************|
    1         G  A  G                                   A  RA          G   ARG   ARAR   G A R
    2         G  A R G                                 AY ARG  A G   AR        G AR    A       R       PAR
    3         A  SAR  G                              Y  A  G   A    G     A R     AR  AR  A  R  PR  PAR
    4         G   AG             A G                 Y   G  A      G     A  R    A   R         PRPR
    5         ARGA G          A      G               Y A G   AR     G     A  R    AR AR        P R     AR
    6         ARGA G             A    G              A  R G  AR     GA  R A    R   A   R      P R
    7         AR  G              A    G              AR   G   A R    A  R  A    R   A   R      P  Y   R
    8         A    G             A G      AR      A R    AR  A    R    A P AR  A     R      PBPY   R
    9         A  R G          A     G                     AR A RA  R    A R     AR          P    AR
   10         R      G                    AG              ARGA RA R              AR        PRP R   A
   11         R          G          A    G ARGA   G  A  RGA RAR                  P   B     PRPR     A
   12         G   A R    G          AR G   ARGAY G AG ARG   AR           P  RBP    B P RPR          A
   13         G   A RGA    RG       AR G      AY GA     RG    AR         B PB PBR  P      R      A
   14         G   AN GP A  RG       N AG      A    R      G  AR      B     P    R    A          R    A
   15         G    N AR A   RG        NA  G  A GAR      Y A R    B          R     A R         A R . A
   16         G       ARG             NA  G  A GAR      A    R   B          R    A    R     AY    R A
   17         G       A GY G     A         G          R          B     R          A R      A Y     R  AY
   18         G       A G        A         GN G       R          B   R            A R                A Y
   19         G      A G         A          NO N Y G R          B   R             A R    AR A G  R   AG
   20         G     A    G       A  NO   GN   GN Y GA        P B    R    A                  G   R  AG
   21         G    AR AG        A       O  G    AG A       R       R   RAY      A   GA       G   A R  G
   22         G  A R G     Y NO   GA         RA            R       B    RY     A      G       A GAG ARAG
   23         G  A        Y    NO  GA      R  A  G  A    R        B    AY     A     G A    G      AR    G
   24         G       C A Y    G  A GA     R  A    G  A  R        B     R   AR   A    R AG  AGA   G    R GAG
   25         NG      A   GN     G N  A    RAR G A         R      B      R      A     R A G    A   G    A  A
   26         D G     A  Y G      N  G     R   G  A GA   R       B      R            A    G    A     G Y  G
   27         G        A   Y   G     N R       G     AR A      R       B    R             A   G      AG
   28         G  AG A    R G         R       G       AR AGR            B  BR             G
   29         G  AG    A R G     Y GA G           A        R          B     R A    R     AG N G              A
   30         GA    G    A RA    Y   GA G          A        R          B     R A    R    A GN G         NG
```

```
31  GA   GAY  AP  A Y   GA   RAG     A     R      .B     R  A        GANG       N
32  G      AY    AR A Y  A      RAG  AG  A        F   AB . R  A  G A   GA G
33  G  3 R A  Y P APA YAG A  R G  AG  A       R  A YB   R  A   GA    G        R G
34  G  -  A      P   A YG    A  R G A    Y A R   AY B   RA        G              AG
35  AS   A Y   F   G   AY AG    AR G AR  R         A Y B   R  A G  .   A    G  A     G
36  AF          ARA  GNYA    G     A GA    R    A       YB    F  A  G     A    GR  A  G
37   R AY AY   PA  N  Y   N G                R    A        B    R  A  G           R AG
38   R  A      GK A N   Y     CG              A  PA       B      R     AG          RG
39   AF AP     A    N A NP     G              A  RA    GAB    R       AG         A RG     AG
40   AY   R Y A  Y  A N O N OG  Y G           A  RA    RB      R        G        A RG     AG
41   Y    A     F AY A N  O  Y A Y AGK          P   ARB    R          G         R G
42   AY     A    R Y  AR A NO  G  K      G K  R     B   R A  RYA  G          AG   N G
43   A       YAY        F   A YNO AR  K  G   K N AR  B   A       G                  N G
44   N  N    ANA  RA         R    AR  K AG   K N AR R    P      A  G
45   C N C  GN AS   YN     AK       AK AY   A YO R B   R  A     G         N G
46   G  KG YG   A R YN    AK      AY   A Y   R  YA  B    RA      G         N G
47   NY KG Y G  AFY  NGA K      AY    A  Y A R  B    R   A    G
48   A  YGN Y NG    YA            R A Y  O  Y   R AB    R    A    G       A   G
49   A GNY   N      GAYAY  A     R    A NGA  R  A  B    R    AR  A     G   YG
50   A        NG     A  Y   A     R     AND AR .  A  B      R        G  RAR AG
51   A  Y A G       A G O R         AG    A R    A  B      R        AG  A G
52   A   GA G A    Y   A R    A G   A    R    A B       R      GAG                    R AG
53   A     NK   A      Y  AR .  GNG    RA R   A B       R      G        RA G             A G
54   A  KAG K     R   A      G N  G  AGR A R  B       A R   A G      R A G N  G
55   K      GNK      ARA G N GN GN    AR  A R B       A  R   A G      RA G    N G N G
56   K     ANA   K  ARA GN G NG O  Y RAYR  B       R        G                  A G .
57   K    A  K     RG     N O G N  Y RAP    B       RA  GA R   G       R  G       A G
58   G K           RG      O NR A   YRAR ARB        R     AY   .  AG    YR AG   A  GAG
59   G  N A   K  G       N  O  R A R   ARA RB       R      A Y AY     A  Y AG    A G
60   NGNKG               NG  A       R  A  YB      R       AYA YAR   AY      AG    A G           RA
61   NGNKG                N  OA      R  B          R         AY AYR   AYR G     R   G
62   G N    G        K   A          R AR B      R         A  Y    R    Y RG    A R   G
63   C       N K        AKA            R  B        R       A GAYAYR AYR G       A    G RG
64   ONC  N GK       A           R   AR   B        R         GR   A YRAYRG           A    G RG
65   GCNGNO NA      . R   AR         A  B     R AR   A   RA       Y   A G        .      A G
66   GC N O    A     F   ARAR       A  B     R      A   RA      Y A G          R G       AY GRG
67   GG       KA   F                B        R       AR A R  AGAG          A  RA  Y  AY     A
68   A Y   A R   ARA   RA R     B          R AR   A   R AP AG       RG  A          Y  G  Y
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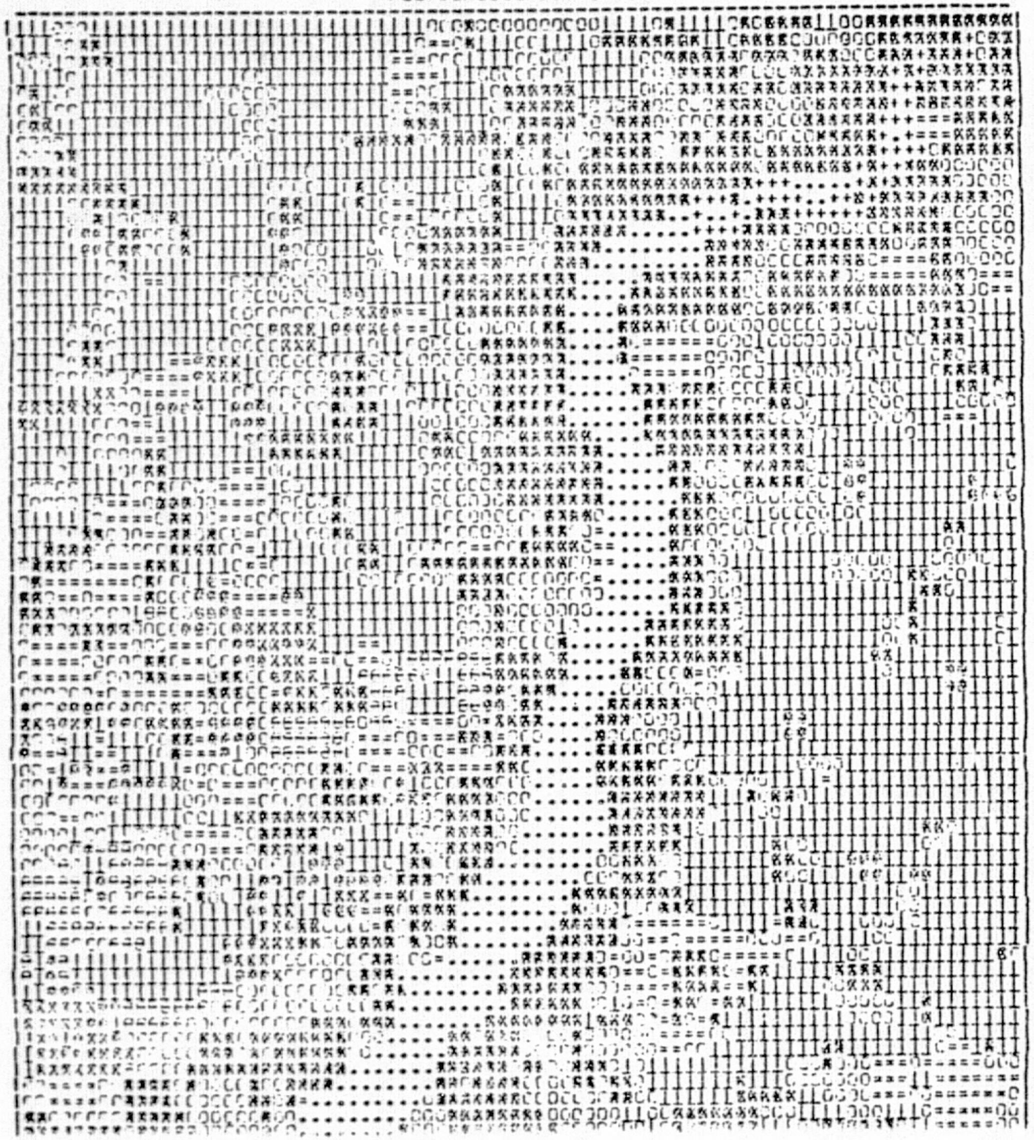
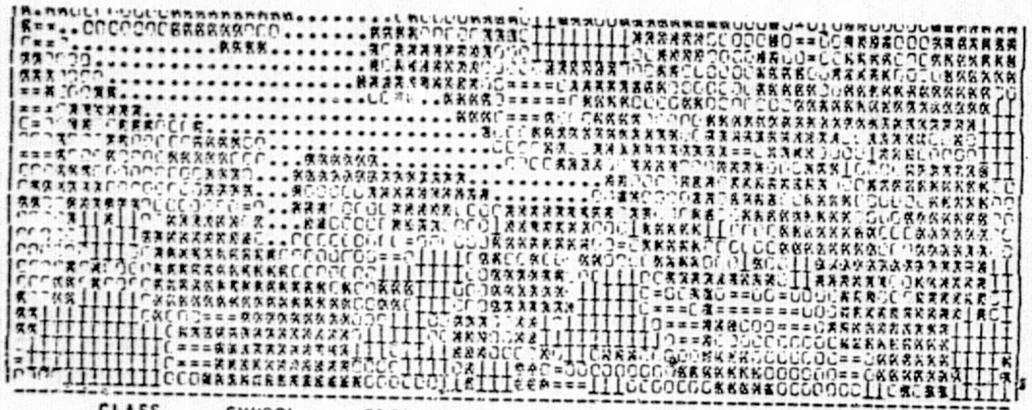
70

AR A R A G R G A Y A Y A
69 A Y A F A R APYB A R A G A R A G A G AY A
70 R I R A RA R A R A GAR G A R AG Y A
71 R AP A NA B RA R A A G AR AR A R A GA
72 R AP A B R A R AG R A R A RAYAGAR A R
73 FRF A R B ARA R A G AG R A RAY A R A R
74 PY B A R A B R A R AG A R A R A YA R A R
75 AY AB R B RAR A G A R R A R A R
76 P A R RAR A R A F A R A R A
77 F A B R A Y AR A R A R G
78 Y I A P B A R B R AY AR A R A R G
79 Y AG B R AY RA R A R A R A RAG
80 AYA F A F A RB RA R A R
81 A RA R A R A B A R A R Y AR A GR A G
82 Y RA RA R A B R B A R AR A F A R GA R G
83 A R A R AB R B R A R AR A R A
84 AR A R B RA R B A R A R AR A R A R A
85 R A P A YAB R A R A R AR A R A R A
86 A FG PG A P ADR R A R A GR A GR G A R A R A
87 A G P AB A YA R A YAR A R A R A
88 A AG A R A Y AG AR A RA R A R A GRA G R G
89 A FAPA P A G A R A G A R AG R A R G
90 A R APA R ARA R G A R AG AYA R AY A YA R A R AG
91 RA R G AR A R AG A R G AY ARY A R GRAG
92 R G ARA Y R A G A R A R GAG AY R A Y AR G
93 R G AR AG A R A R G AY RA R G
94 AG AY R G AG R A RAG AR A R A Y AR R
95 YG AY R A G ARG N AYA R A Y AR G R
96 A G A R A G RG N Y G A R A G ARAR G

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE

ALL CLASSES DISPLAYED

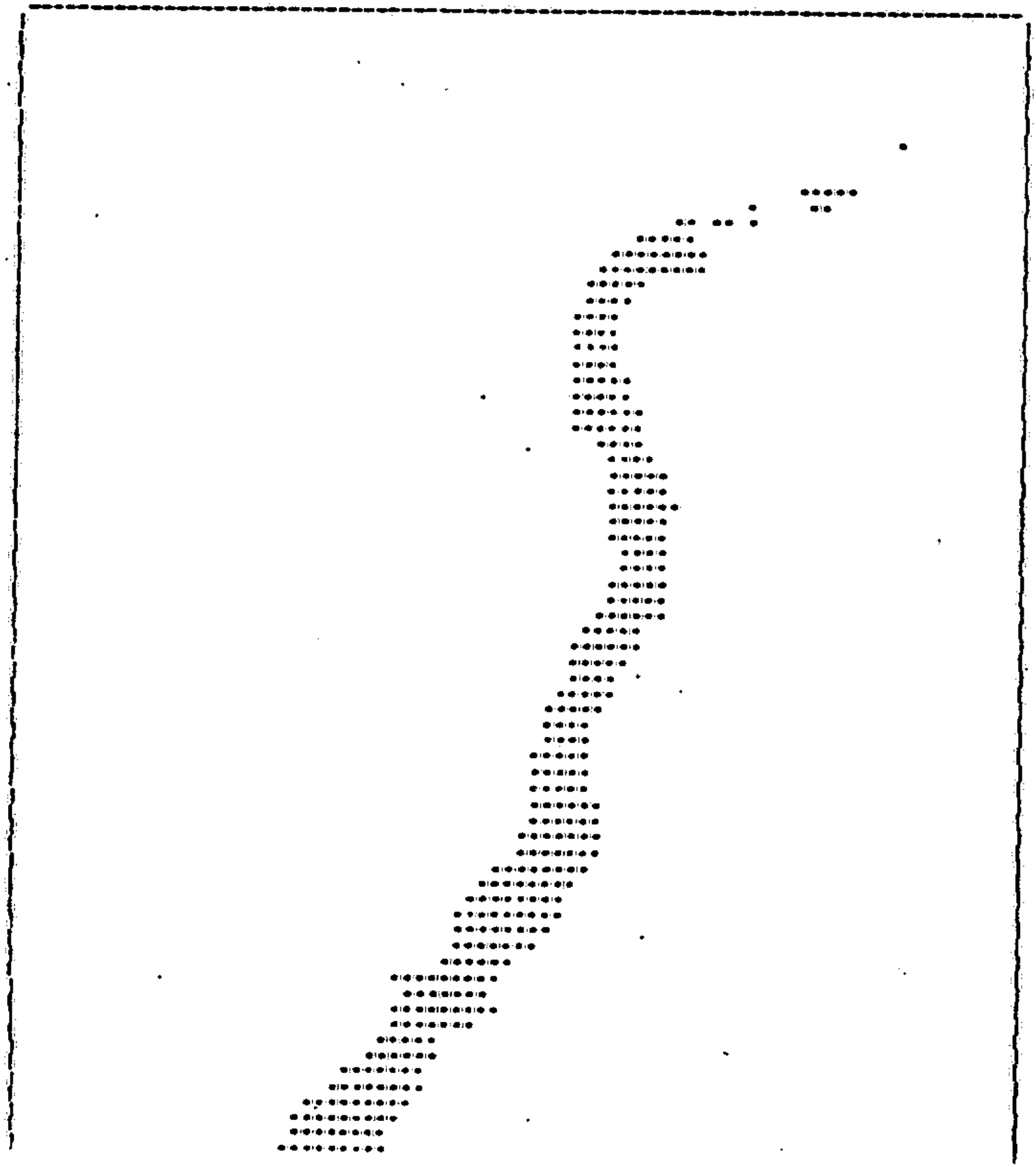


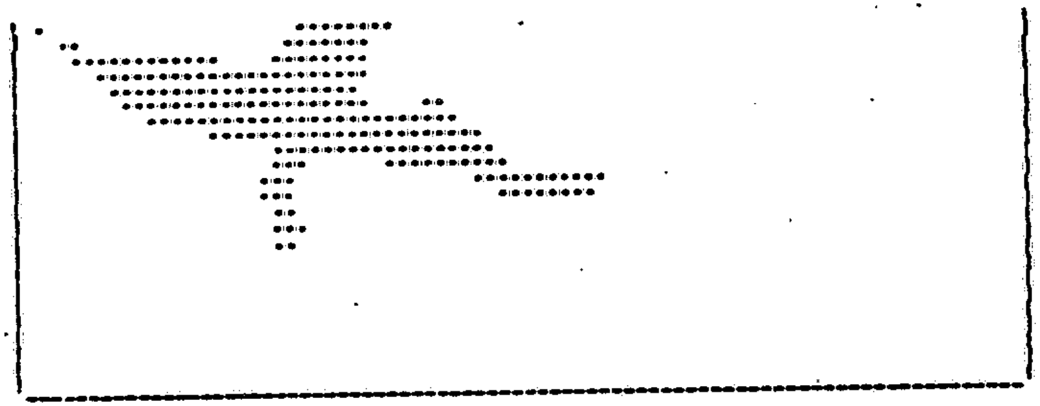


CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
1	...	579	0.09	7.5
2	===	412	0.06	5.4
3	+++	48	0.01	0.6
4	OOO	2023	0.32	26.3
5	III	1989	0.31	25.9
6	ΘΘΘ	125	0.02	1.6
7	XXX	99	0.02	1.3
8	ΘΘΘ	170	0.03	2.2
9	XXX	2235	0.35	29.1
		7680	1.20	

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE

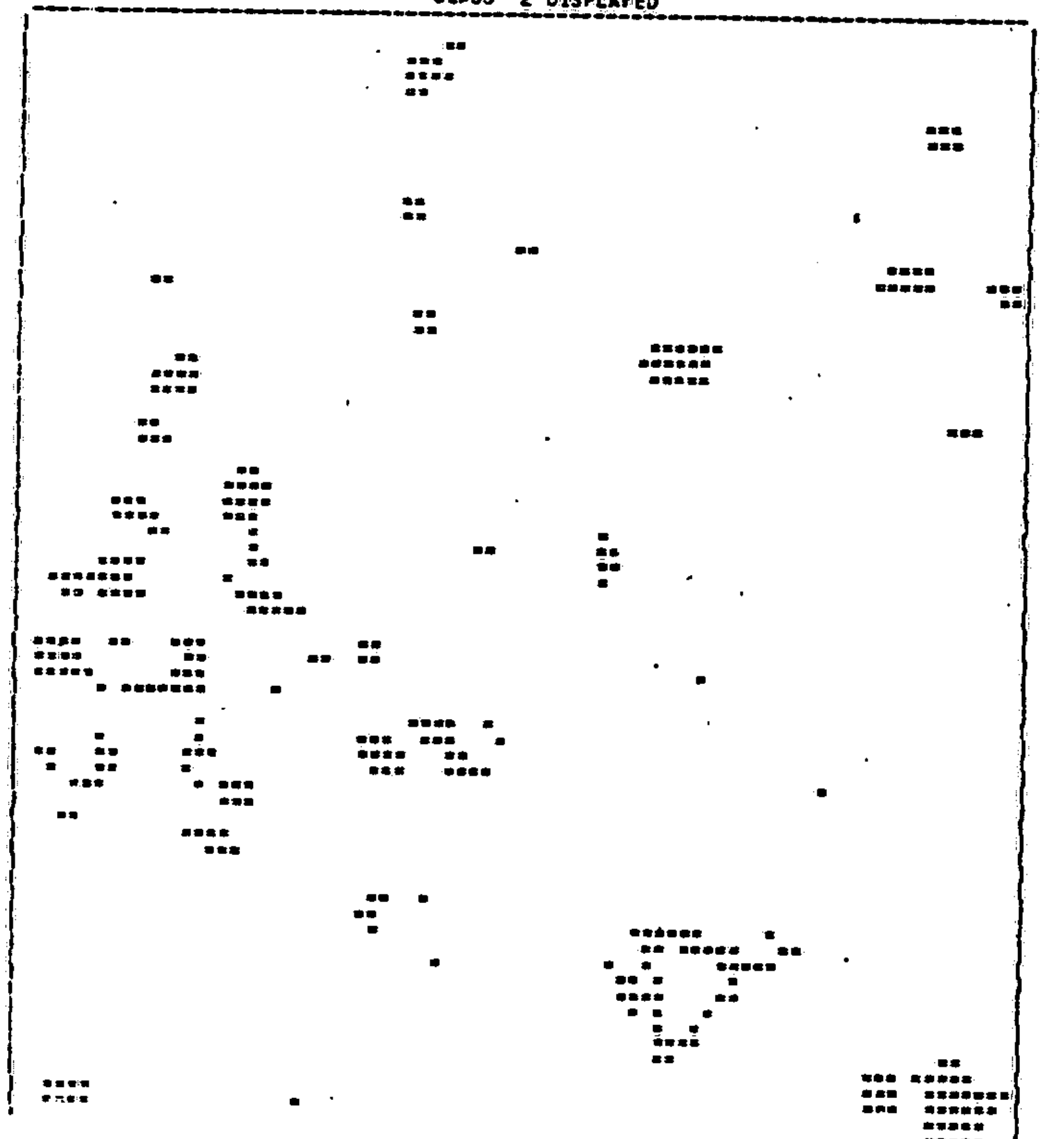
CLASS 1 DISPLAYED

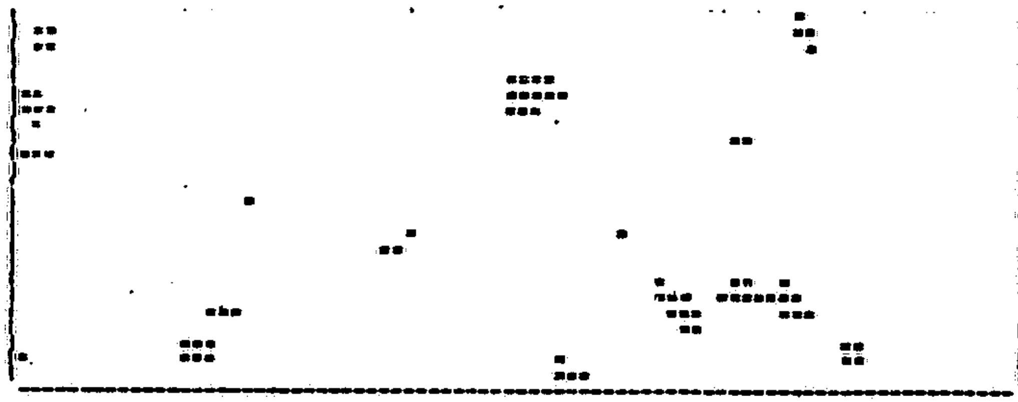




CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
1	•••	579	0.09	7.5
		7680	1.20	

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE
CLASS 2 DISPLAYED

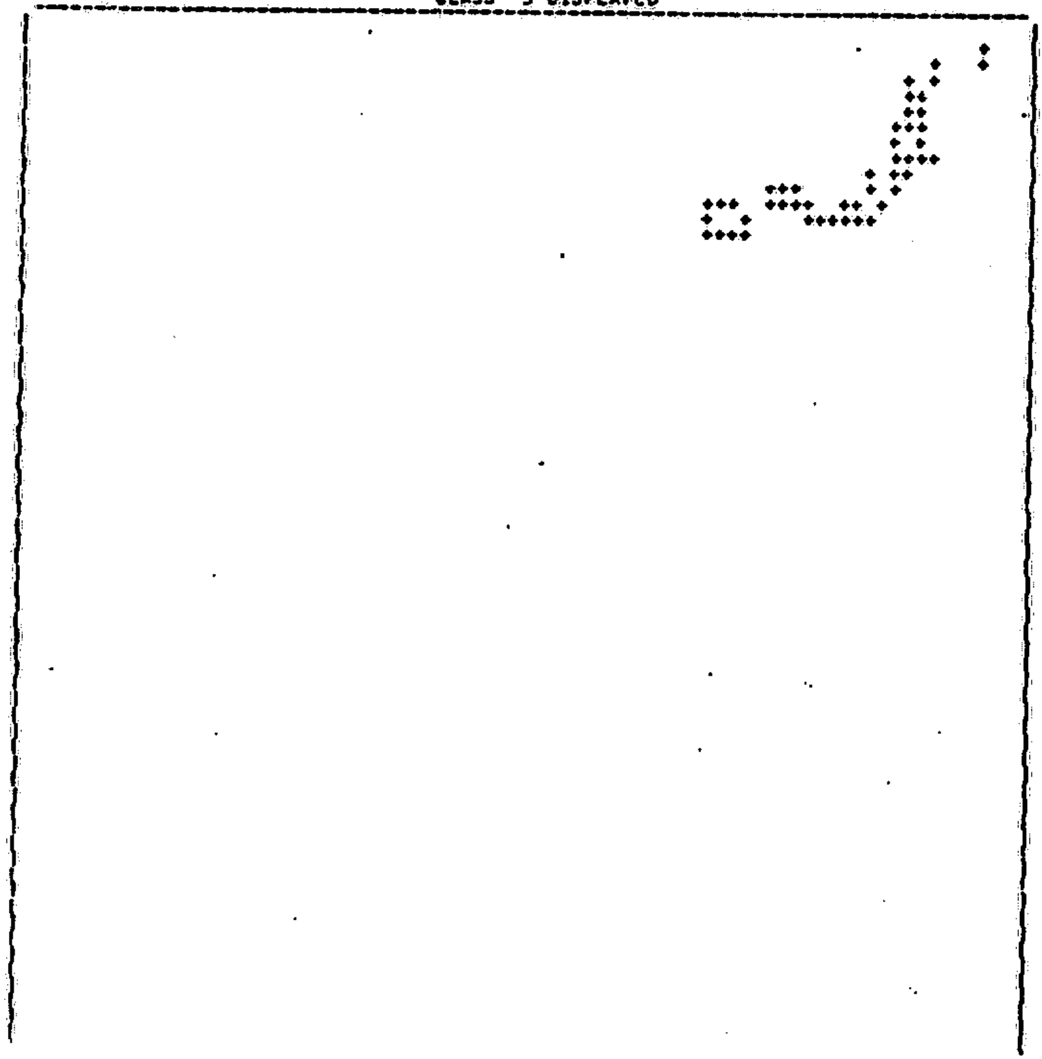




CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
2		412	0.06	5.4
		7680	1.20	

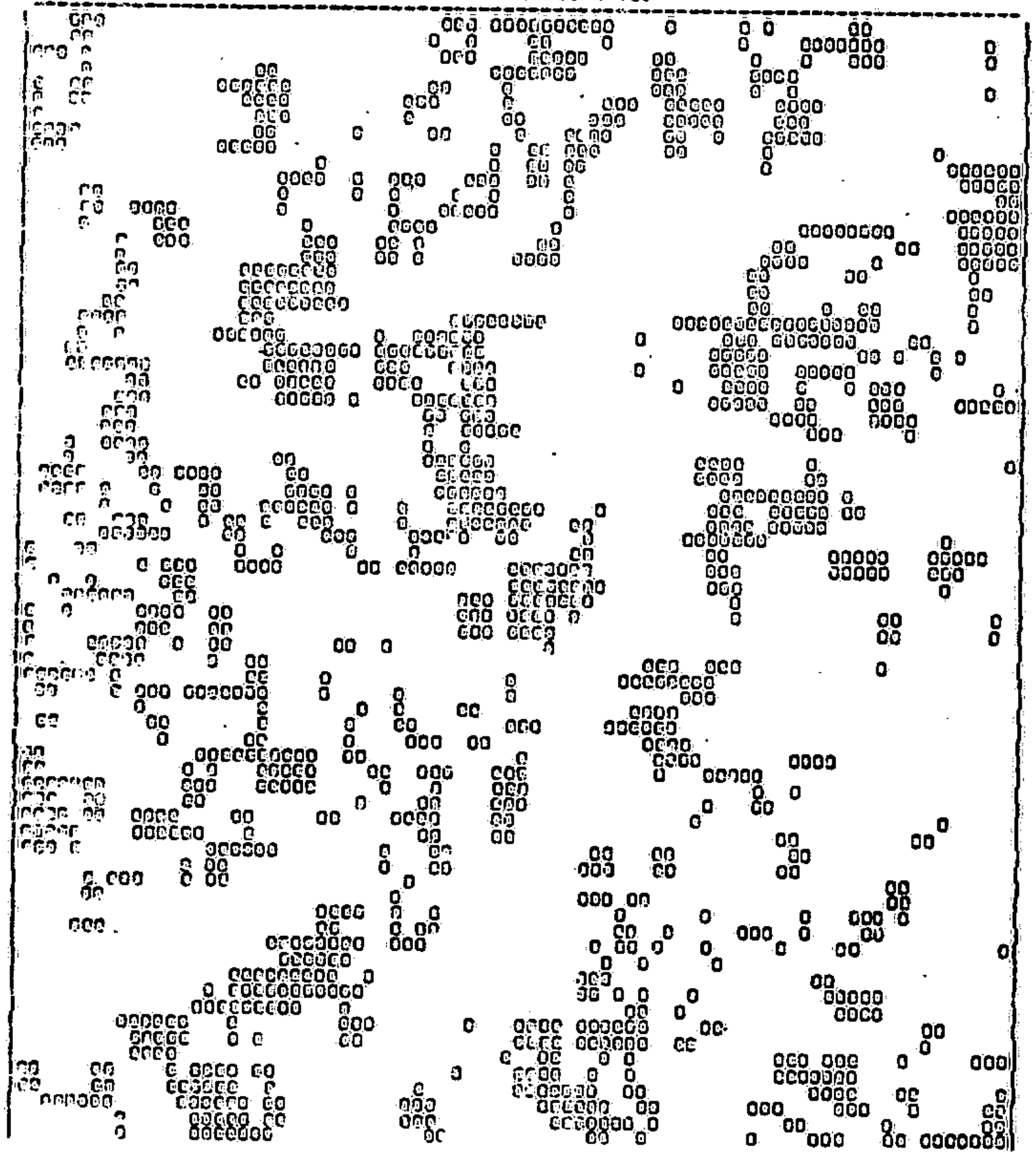
LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE

CLASS 3 DISPLAYED



CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
3	+++ +++ +++	48	0.01	0.6
		7680	1.20	

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE
CLASS 4 DISPLAYED



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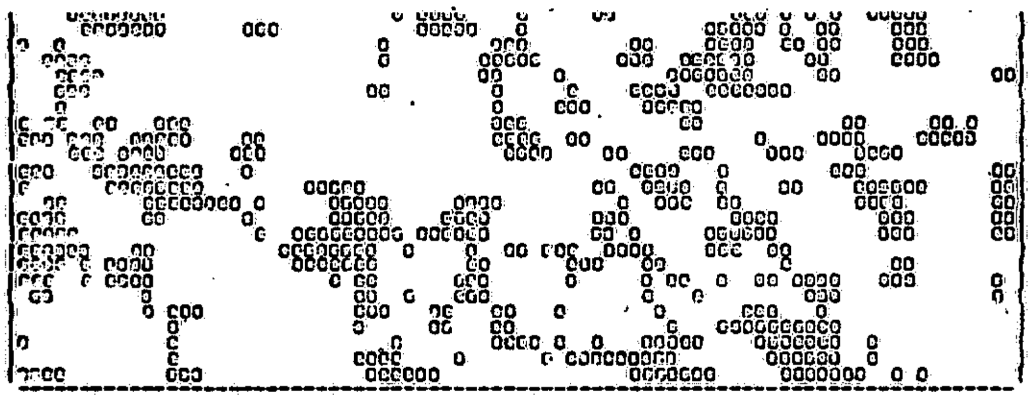
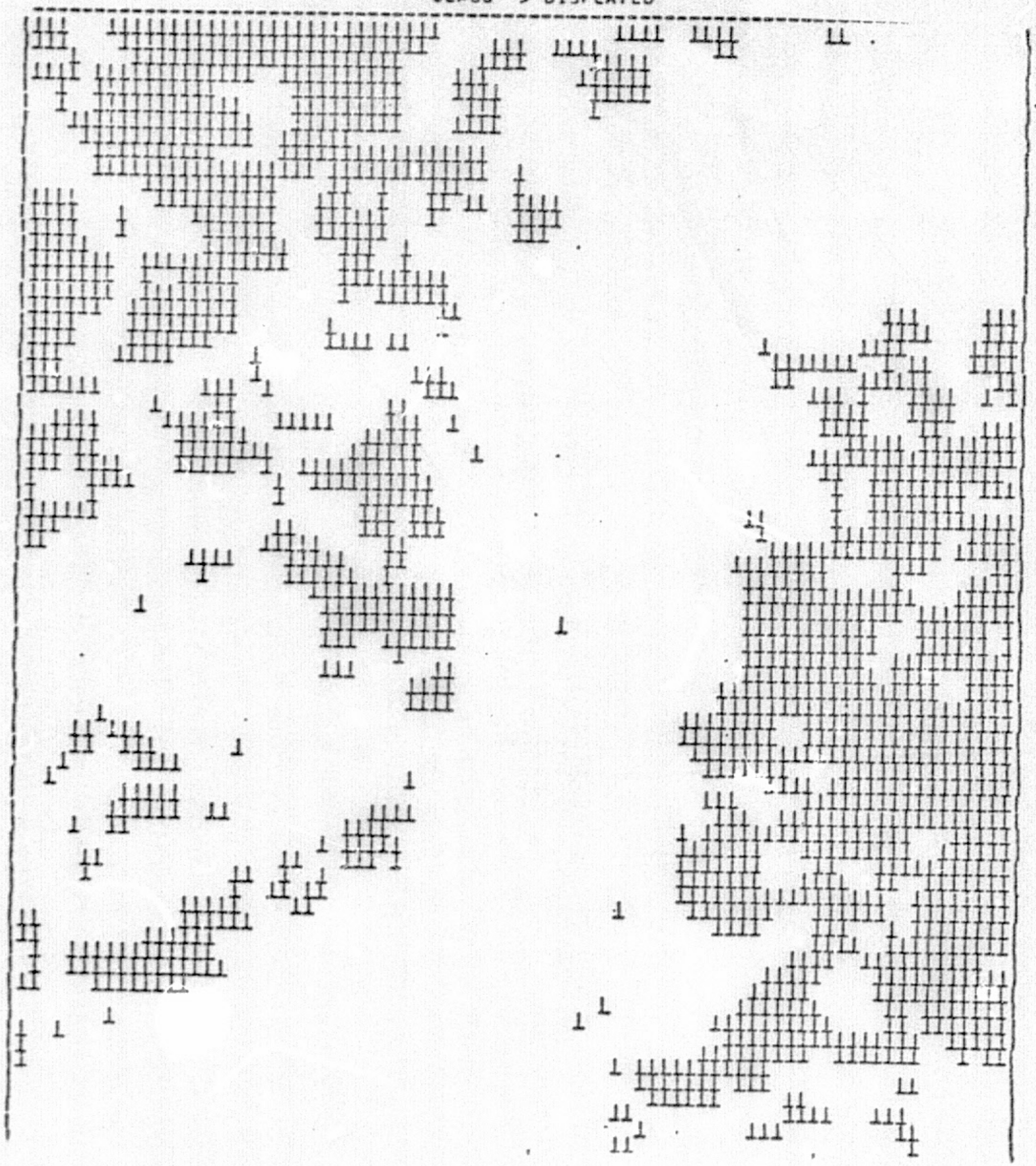
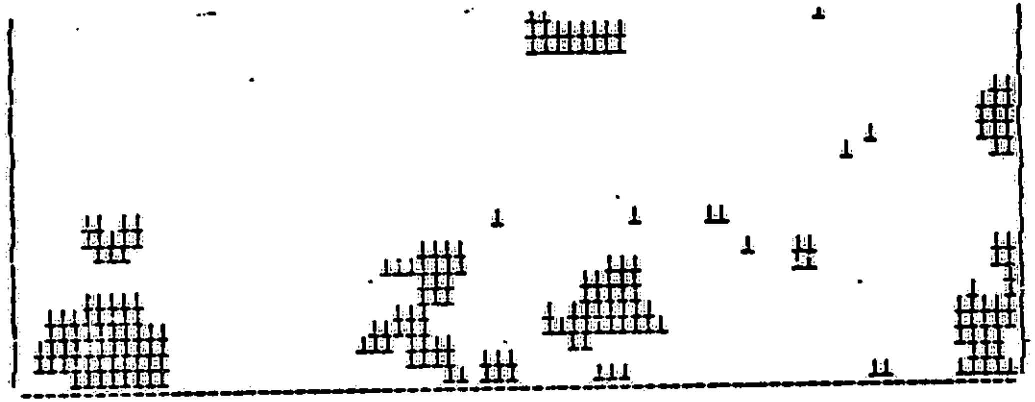


CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
4	000 000 000	2023	0.32	26.3
		7680	1.20	

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE
CLASS 5 DISPLAYED



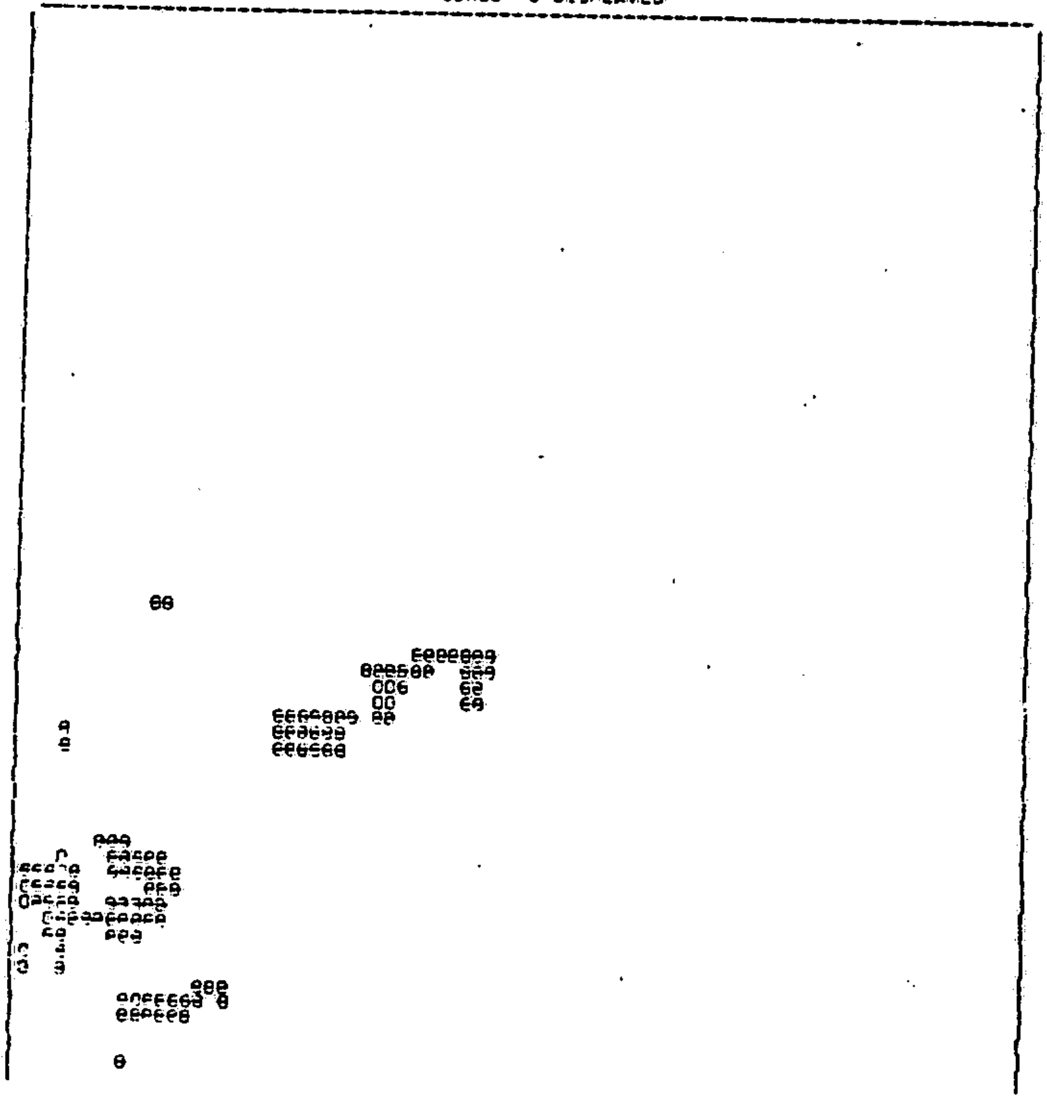


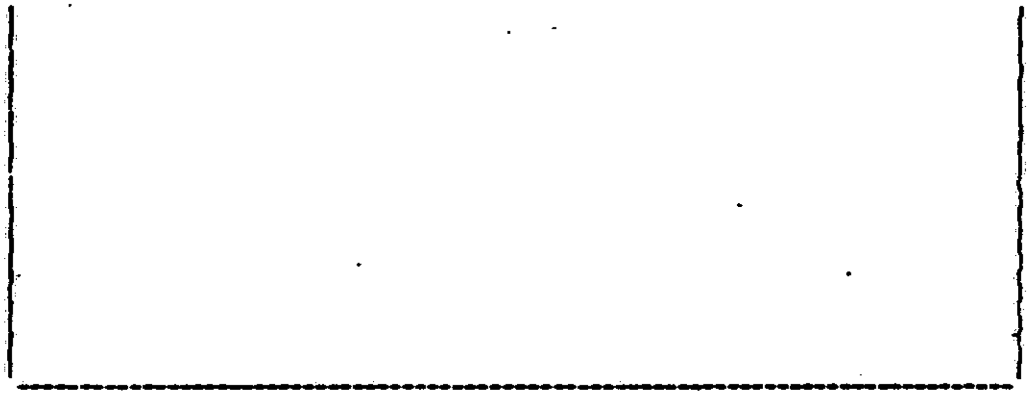
CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
5		1989	0.31	25.9
		7680	1.20	

C2

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE

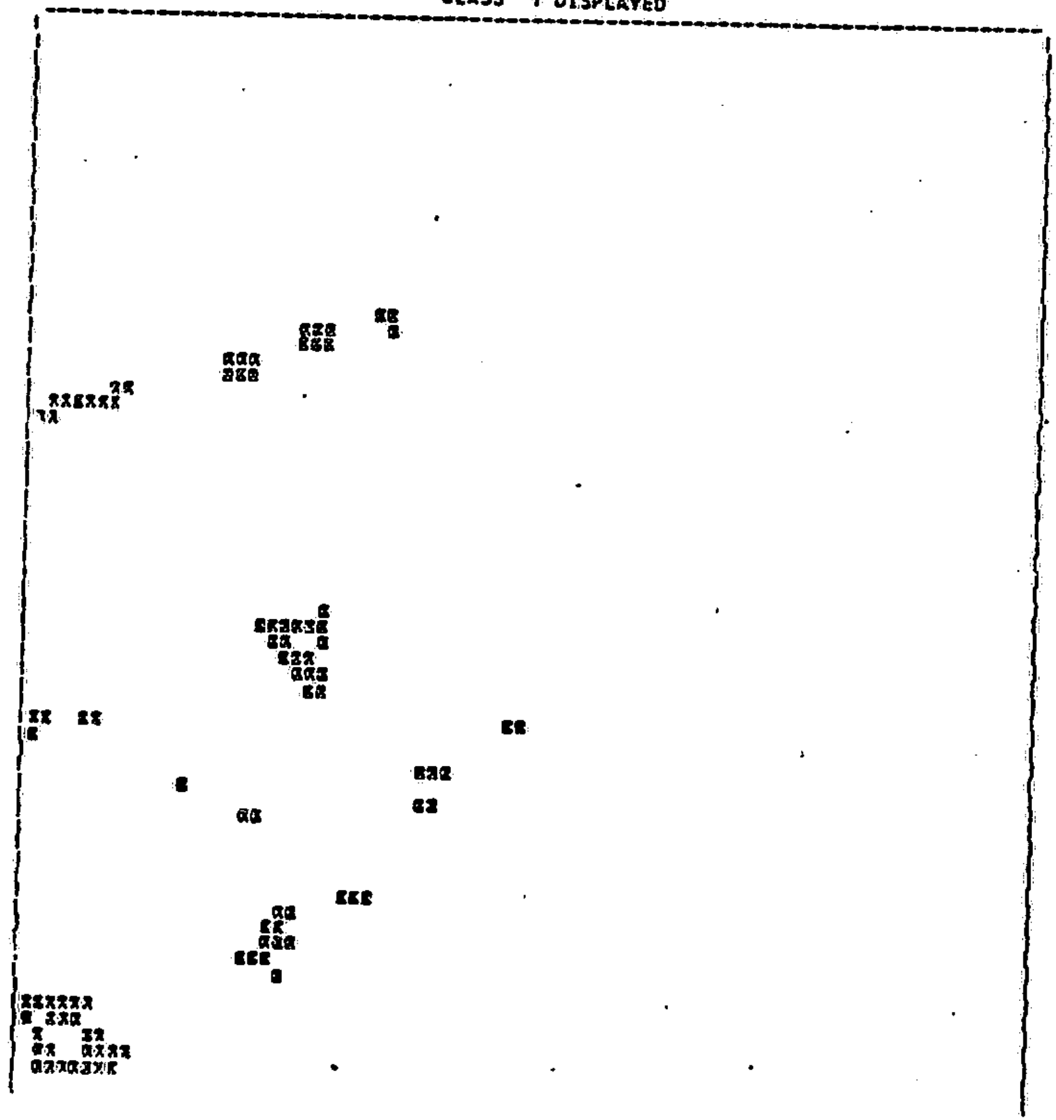
CLASS 6 DISPLAYED

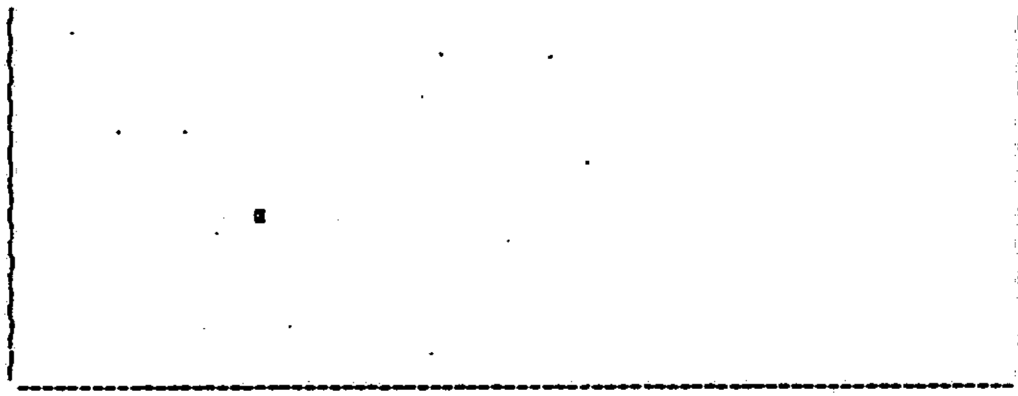




CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
6	OE@	125	0.02	1.6
		7680	1.20	

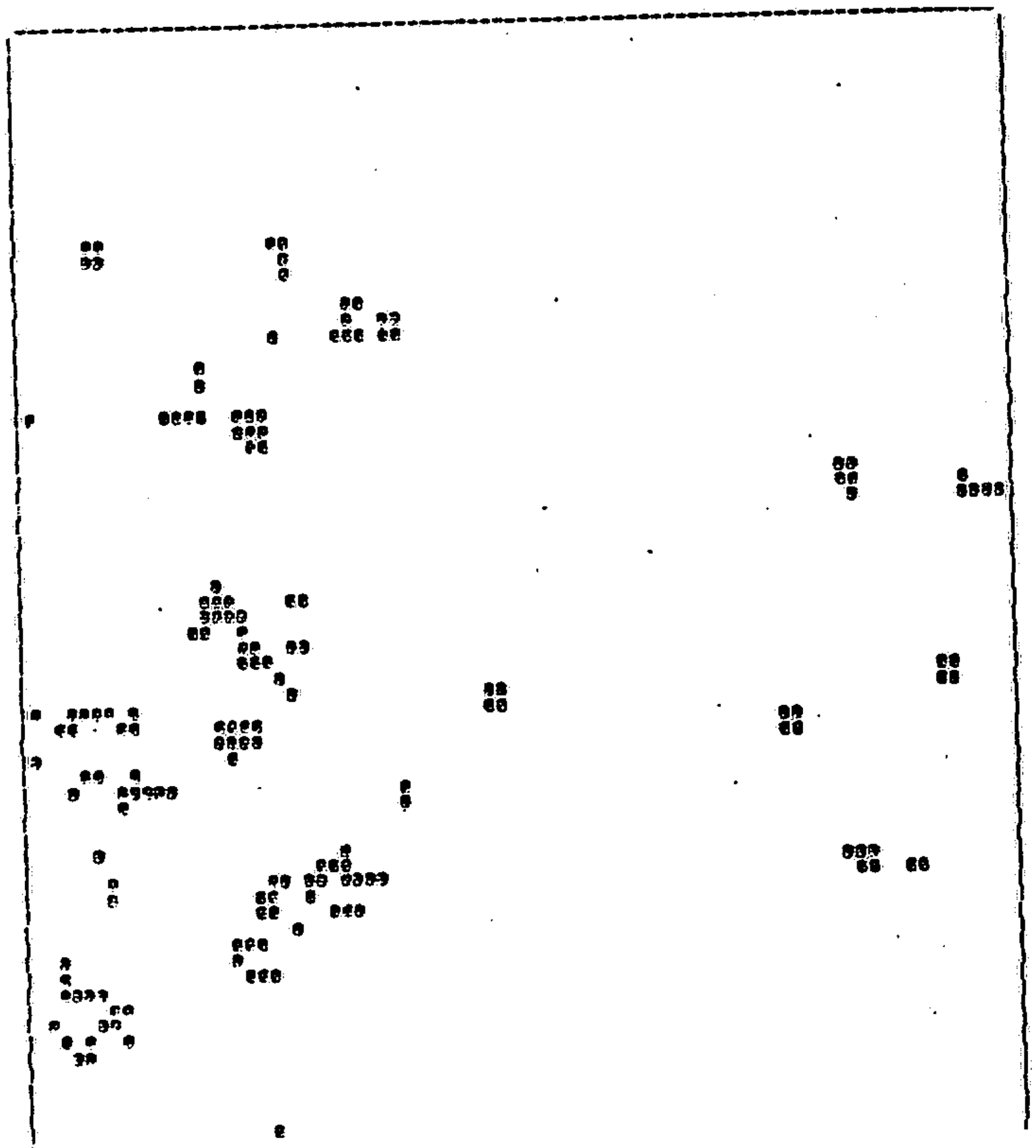
LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE
CLASS 7 DISPLAYED

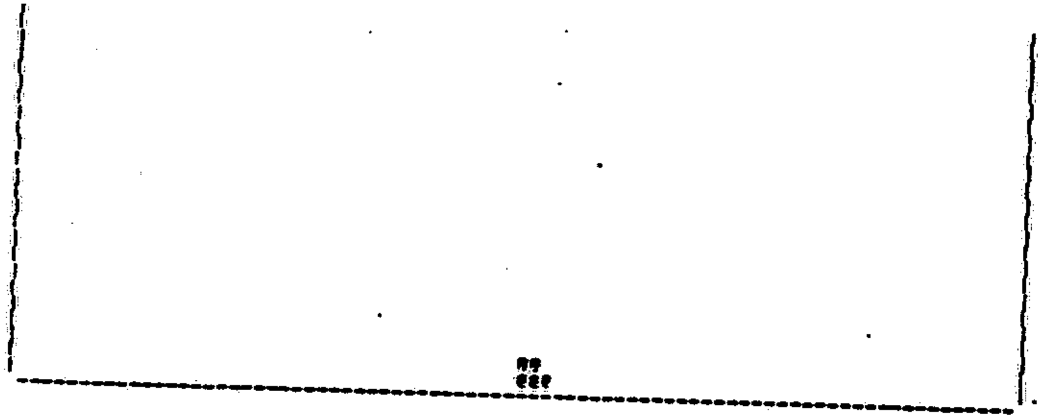




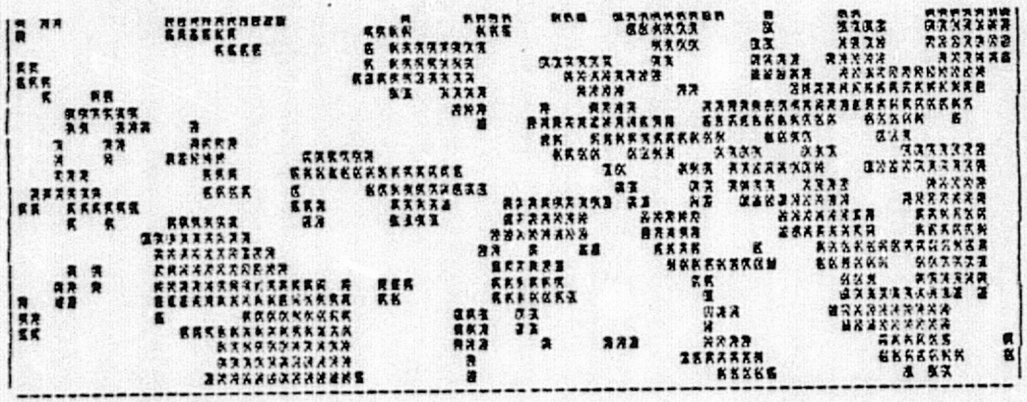
CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
7	[illegible]	99	0.02	1.3
		7680	1.20	

LAKE DECATUR-ERTS SATELLITE MAP FROM ENHANCED IMAGE
CLASS 8 DISPLAYED





CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
8	888 888 888	170	0.03	2.2
		7680	1.20	



CLASS	SYMBOL	FREQUENCY	AREA(SQ MI)	AREA(P.C.)
9		2235	0.35	29.1
		7680	1.20	

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